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PROGRAM manager

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PROGRAM Manager

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The third edition of a popular DSMC publication goes to press. The text is revised but the basic objective remains unchanged.

Whenever in this publication "man," "men," or their related pronouns appear, either as words or parts of words (other than with obvious reference to named male individuals), they have been used for literary purposes and are meant in their generic sense.

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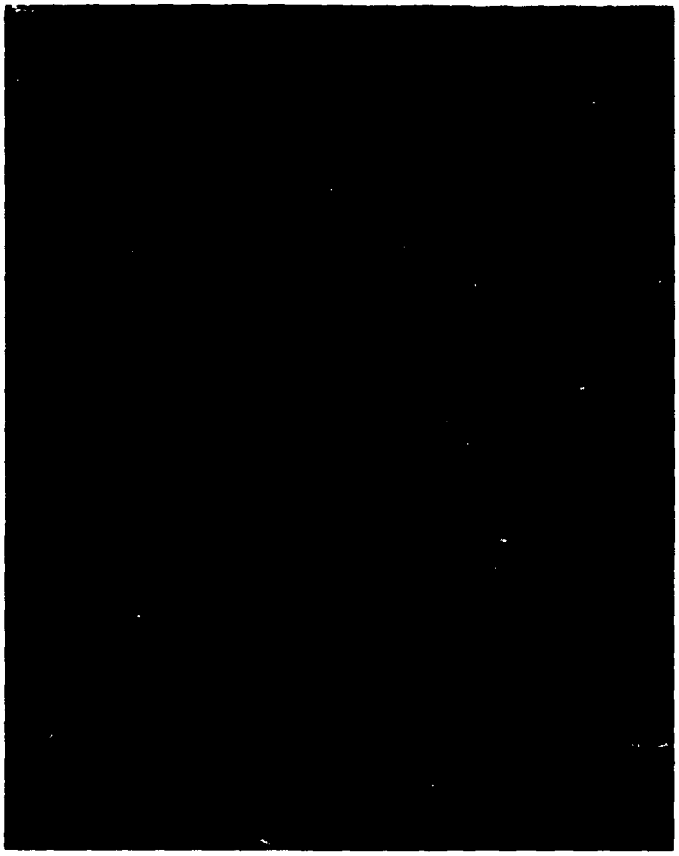
ENVIRONMENTAL POLICY:

AN OIL SLICK FOR THE PROGRAM MANAGER

Roland H. Williams

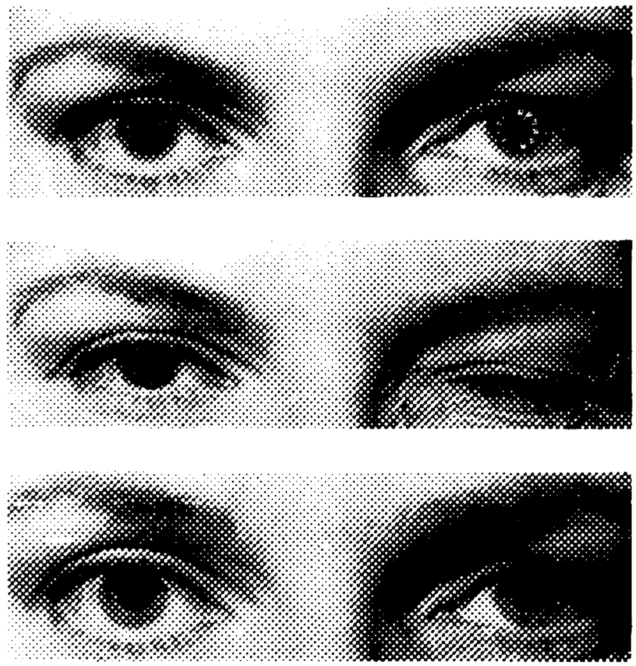


The first part of this article deals with the problem of understanding. It is late in the first term of a popular U.S. President's administration. In the technological world, concepts and inventions have intersected in time and space, spawning possibilities for software and machines to accomplish feats thought impossible and, until now, science fiction fantasy. Military leaders recognize possibilities for application to our defense program. A way exists to counter the most terrible and unstoppable threat our adversaries have been able to deploy. It will be expensive beyond comprehension of the human mind but the facts are there, technology has been tested, components can be manufactured, and we can make it work.

The U.S. President is reelected in a wave of popular support. He fully supports developing a defense system based on the new technology and orders a program to be initiated at once, while riding the crest of congressional backing. A high-level program manager (PM) is appointed. The PM can pick the best and brightest program operatives in the country, military and civilian. The "number crunchers" prepare a budget request that should be approved in record speed. Scientists and technicians are reassigned, priorities shifted, and resources are available to the program on a scale unprecedented in peacetime. The program office begins drafting contract requirements, selecting high-tech industries for developing finished hardware, and makes plans for deployment of the system on fixed scheduled dates. It all can be done so fast that our adversaries could not possibly make a counter move. We would surely enjoy a military advantage for the forseeable future.

Then, a lawsuit is filed by an obscure lobby organization charging the Defense Department with failure to conduct an environmental assessment before proceeding into Milestone I, in violation of the National Environmental Policy Act. A judge agrees. The program stumbles. Opposition in the Congress has time to coalesce. Political opponents are able to whip up an emotional objection to the huge sums of money necessary to fully deploy the system. Scientists with negative opinions of the technology and citizens philosophically opposed to advances in the art of warfare have opportunities to make their cases to the media. Funding is delayed. Other programs make a plea for the resources. The program becomes a major political issue, a bargaining chip to be traded for parochial projects and regional interests. The entire program is now smoking and sputtering as if it were hit with one of its own super-sophisticated, high-tech, high-speed, high-energy projectiles.

Names were left off the program described to protect the author, but it is true. Why? How is it that a seemingly insignificant administrative mistake can totally alter national



defense strategy and dictate the course of something so vital to the survival of this country as weapon system development?

Unfortunately, this is not an isolated case. In fact, it is often faced in major acquisition programs. Smaller, less ambitious programs are more successful at evading public interference on environmental grounds because they get less publicity and environmental problems generated are small in comparison to the billions of dollars lost by the Defense Department every year through failure to comply with environmental protection laws of the United States. The waste is criminal. Literally.

The irony in this massive and needless squandering of time, effort and money is twofold. First, it violates laws everyone agrees with. The American public supports environmental protection by an overwhelming majority, even to the point of being willing to pay extra for it. The Commander in Chief has ordered it; the Secretary of Defense has reinforced it; and military personnel are, individually, one of the most ecologically sensitive groups on earth.

Second, protection of the environment is not in conflict with national defense; in fact, it is complementary, increasing our defense posture. The word "environment" encompasses everything around us—land, water, air and, most important, people and is no less than what we are defending in the first place.

The Order with a Wink

My first assignment in a military organization was in the office of a Vice Admiral. I learned the first day that two orders are universally disobeyed—"Don't stand up," and "Call me Pete." For some reason rooted in American industrial and military culture, orders to comply with environmental regulations are accepted with the same tacit understanding that they are to be disregarded. There is a widely held belief that there are other, higher priorities, and that it is faster-cheaper-better to do the job first and worry about the environment later.

You would expect there would be a moral conflict between one's desire to be an environmentally conscious person and the duty to accomplish a task efficiently without regard to personal beliefs. Most military personnel are, almost by definition, people who love the natural world. They get involved in outdoor activities, support conservation groups and public improvement projects. They are campers, sportsmen and athletes. A scout troop near a military establishment often has a majority of its adult leadership comprising military personnel, who work with and teach environmental awareness to the next generation of Americans. If you imply they are not environmentally oriented, military personnel usually take offense.

A military training must, of necessity, teach Service people to put aside their beliefs for the greater good. Government managers learn to put the public first. The acquisition manager, in particular, spends most of his career in the public fish bowl, and knows that religion, prejudices, and politics don't enter the work place. One *never* gets personal finances mixed up with government funds.

Furthermore, officers and managers who are promoted to positions of responsibility in acquisition programs are usually dynamic, action-oriented, results-focused leaders who have demonstrated they can get things done. The morass of bureaucracy does not get in their way. Consequently, environmental concern is left at home and the directive to comply with environmental laws is put on a long list of insignificant special-interest items with neither time nor resources permitting them to be incorporated into the program.

The Scorched Earth

When General William Tecumseh Sherman set out to starve the Confederacy into submission by laying waste to the land, he didn't start his famous March to the Sea in Chicago. He had good, sound military reasons for starting where he did. To paraphrase a quote from General George S. Patton: "You don't win a war by destroying your own country, you win it by destroying some other poor dumb (expletive deleted) country."

It may seem a contradiction to think of weapon systems as environmentally sound. Weapons are supposed to be harmful—at the receiving end. The value of a weapon system is usually measured by its destructive potential. It is inevitable that the devastatingly powerful systems being designed, manufactured, and deployed today must be made from materials that are harmful and difficult to deal with. It is a fact that any manufactured material, or any act of man that alters the natural world, is potentially harmful and can have catastrophic effects on the human population.

There is no need for me to repeat details of destruction to the environment caused by past mistakes. The multibillion dollar bill for clean up speaks for itself. There probably isn't a reader of this journal who doesn't know a better place that money could have been spent.

Cost alone is not the concern here. Weapons in the field would work *better* if attention was given early in their developments to the relationship between hardware and the environment. Factories building weapons would be better prepared for mobilization if they hadn't been contaminated in peacetime. Materials needed in an emergency would be available if they hadn't been squandered, and the skilled technicians would be ready to replenish our supplies if they hadn't been poisoned. Combat and support personnel could react faster, concentrate better, and be more effective if they didn't worry so much about hazards of transporting, handling, and using their weapons.

The American military establishment is aware of the trust it holds and its responsibility as keeper of the force capable of destroying life on earth. We are beginning to realize we have a process that could have the same result if we do not act quickly to reverse the trend; this process *is underway* and we have not fired a shot. The initiator was our industry and technology, and the American defense establishment as proponent for a major segment of that industry is accountable for much of the problem and must lead in returning to a course to keep this planet habitable.

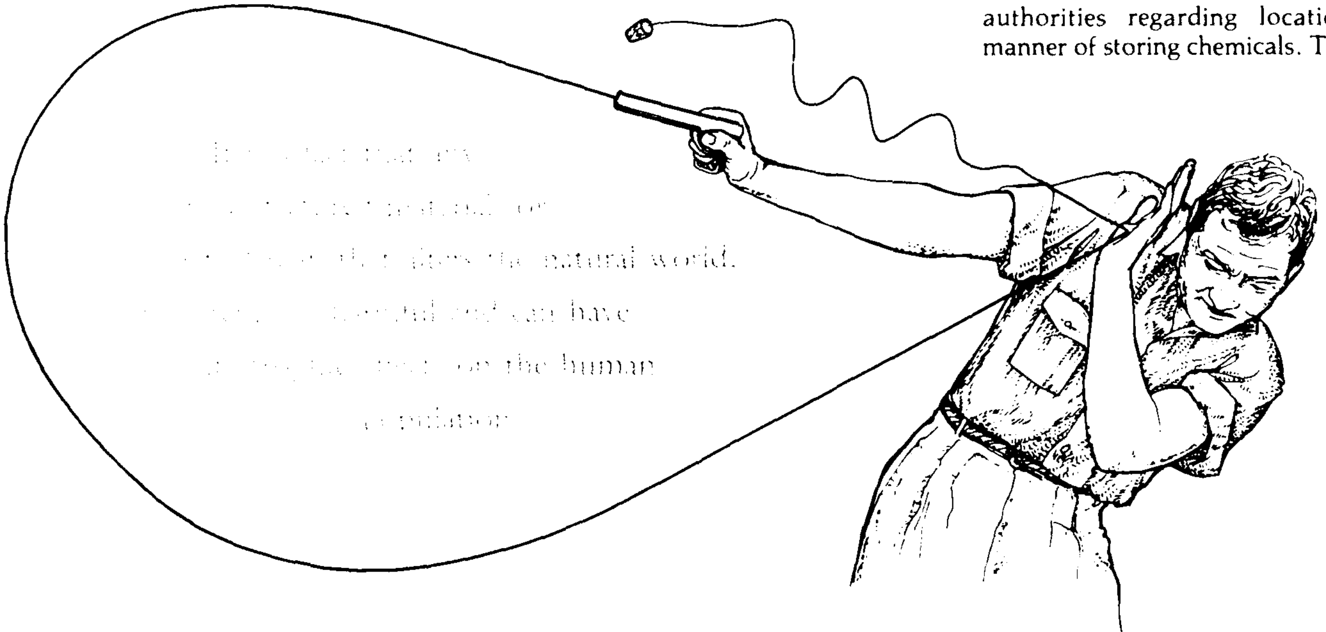
It's Not My Fault

Fixing responsibility for past mistakes and for the changeover to a new way of doing things is not easy. How does a program manager fit into the scope of compliance with environmental laws?

Responsibility often shares a problem with military property regarding the environment. The military controls a lot of land; the public has a lot of environmentally undesirable waste to dispose of. Yet, this land belongs to the U.S. Government and, in essence, everybody, and is an attractive target for toxic waste dumping. Responsibility delegated to "everybody" is usually, in effect, "someone else's."

The Department of Defense is late in reacting to public demands for better environmental awareness. In spite of its stated goals and the directive to personnel to obey environmental laws, DOD has been slow to set up effective communication, execution, and reporting channels. The DOD is paying a heavy price in dollars and decreased capability. Individuals within DOD not heeding the directive are paying fines and facing jail sentences.

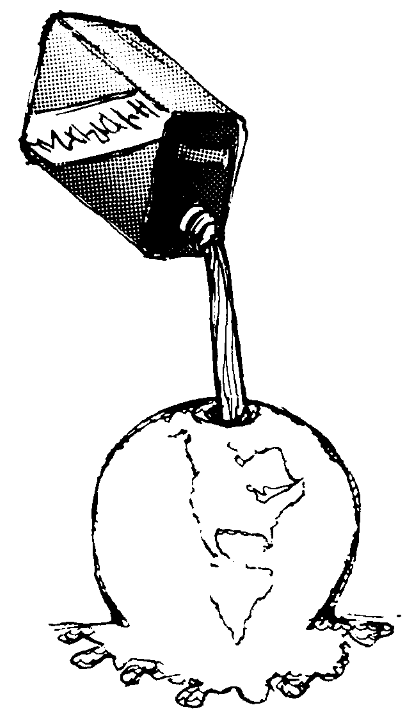
In 1987, a maintenance foreman told his crew to dump paint cans in a pond on a firing range; he has been convicted on 2 of 37 counts of violating the Clean Water Act and faces up to 6 years in prison. In 1988, a major command's research facility had an altercation with local natural resources authorities regarding location and manner of storing chemicals. The com-



mand's procedures were older than the law in question but it didn't have a permit; three senior officials were indicted and face up to 21 years in prison and hundreds of thousands of dollars in fines. When workers at a naval repair facility dumped forbidden material into a river, the installation commander was named in a civil suit and held *personally* liable for damages totalling millions of dollars. In all cases, the Judge Advocate General ruled since it is illegal for the government to be on both sides of a case, the military service involved could not provide a defense, even if it supported the individuals. Personal costs to the defendants were astronomical in money and self-esteem.

Major research programs, initiated to develop countermeasures to new weapons known to be developed and deployed by Warsaw Pact Forces, have been delayed by court order because of the failure of program managers to conduct valid environmental assessments and file necessary paperwork before starting new activities. The cases brought so much public opinion to bear that portions of planned research were abandoned rather than wage a public relations battle that could risk the entire program. Because of an administrative oversight, U.S. armed forces may be vulnerable to a genuine enemy threat.

When todays advanced fighter aircraft were being developed in the 1970s, the prime objective was performance. "Performance" was defined as successful execution of the task at hand and became a laboratory definition. One of the aircraft's components is an emergency power supply using hydrazine as oxidizer for the gas generator. Other materials would work almost as well but hydrazine was the best. Now we have to deal with a logistical nightmare—transporting, handling, and storing a poisonous, eye-burning liquid that emits toxic fumes at room temperature and will eat its way through most containers. We are restricted on locations to deploy these



aircraft because we lack specialized facilities to handle one small, but important component of an extremely complex weapon system.

A common denominator in these catastrophes is that perpetrators and proponents thought they were doing their jobs. The alarming part is that these are not isolated or typical examples but represent the way the Department of Defense has, and is, doing business. In researching this article, I tried to find a good example where the environment was considered from the start of a program, resulting in a finished product that was safe, hazard-free and effective. I solicited input from offices dealing with environmental issues at the highest levels of the Services and DOD and several major commands responsible for weapons systems acquisition. They *couldn't* provide one.

The time for change is *now*. Environmental laws have been on the books since the Rivers and Harbors Act of 1899. Modern environmental laws were developed and passed by the Congress in the late 1960s, with loopholes closed and new legislation passed in every congressional session since. Many people, in industry and government, have not taken the law seriously. The laws are so new that, as a society, we don't have the communications and enforcement structure fully in place. It has been expedient to ignore the law.

Environmental protection laws were thought by many to be a partisan political issue, instigated by the free-spirit movement of the '60s and not supported by mainstream American beliefs. It was a major surprise to some people when the Reagan Administration, early in its first term, strengthened enforcement authority of the Environmental Protection Agency, initiated a cooperative effort with the Department of Justice, and prosecuted violators. Since then, the scientific community has been gathering and publishing data that irrefutably demonstrates the danger of damaging the environment. Disasters at Bophal, Chernobyl, Love Canal and other places underscore the potential for universal harm, and strengthen public support for an effective national policy which is strongly enforced. Environmental law is here to stay.

No one has earned the badge, yet...

The duty of the program manager is to develop, acquire and deploy a system contributing to the best defense of this country. You will not succeed if you do not consider the relationship of your system to the environment within which it will be built and operate.

Fear of the law, a good reason to integrate environmental consideration into your program, isn't the best reason. All systems, even weapon systems, operate in an environment. They are a component part of that environment, even if their functions are to destroy when called upon. How well that system will work and how effective it will be depend on how well the system functions relative to its supply line, physical surroundings, and human operators.

As a manager of a systems acquisition program, you can exercise far-reaching control. You may not have to face the disposal problem. An installation commander "somewhere else" may have to dilute resources to manage administrative tasks dealing with a hazardous material *you* decided "provides the best performance." If laws, directives and regulations are ambiguous regarding the responsibility of others dealing with the environment, they should be clear to *you*. The duty of the program manager is to develop, acquire and deploy a system contributing to the best defense of this country. You will not succeed if you do not consider the relationship of your system to the environment within which it will be built and operate.

Part II. Compliance: You Are On Your Own

The first thing learned when assigned to manage an acquisition program is that you don't have, and won't get, enough resources to do the job the way you choose. Among things you won't get, and probably can't find, are specialists dealing with environmental considerations. The problems are complex with dozens of technical fields of study to be found in environmental science. Environmental law is just as complex. The Code of Federal Regulations volume listing all laws concerning Protection of the Environment, CFR 40, comprises 20 books, 3-feet thick. You don't have to know everything but you *do* need to know obligations, liabilities and resources to assist. The best configuration for the product your program is charged to develop and deliver will be natural for you; engineering skill and management expertise are all you need. Once you consider the environment as an integral part of the design, its value and importance become obvious.

"...There is a natural bond between those who work to protect our environment and those who work to protect our national security. Both believe in the future, both refuse to accept the notion that decay—either in the quality of our environment or in our national defense posture—is inevitable. The same men and women who are committed to protecting American's freedom are also committed to ensuring that we enjoy that freedom in a clean and healthy world."

—Frank Carlucci
Secretary of Defense

Priority One

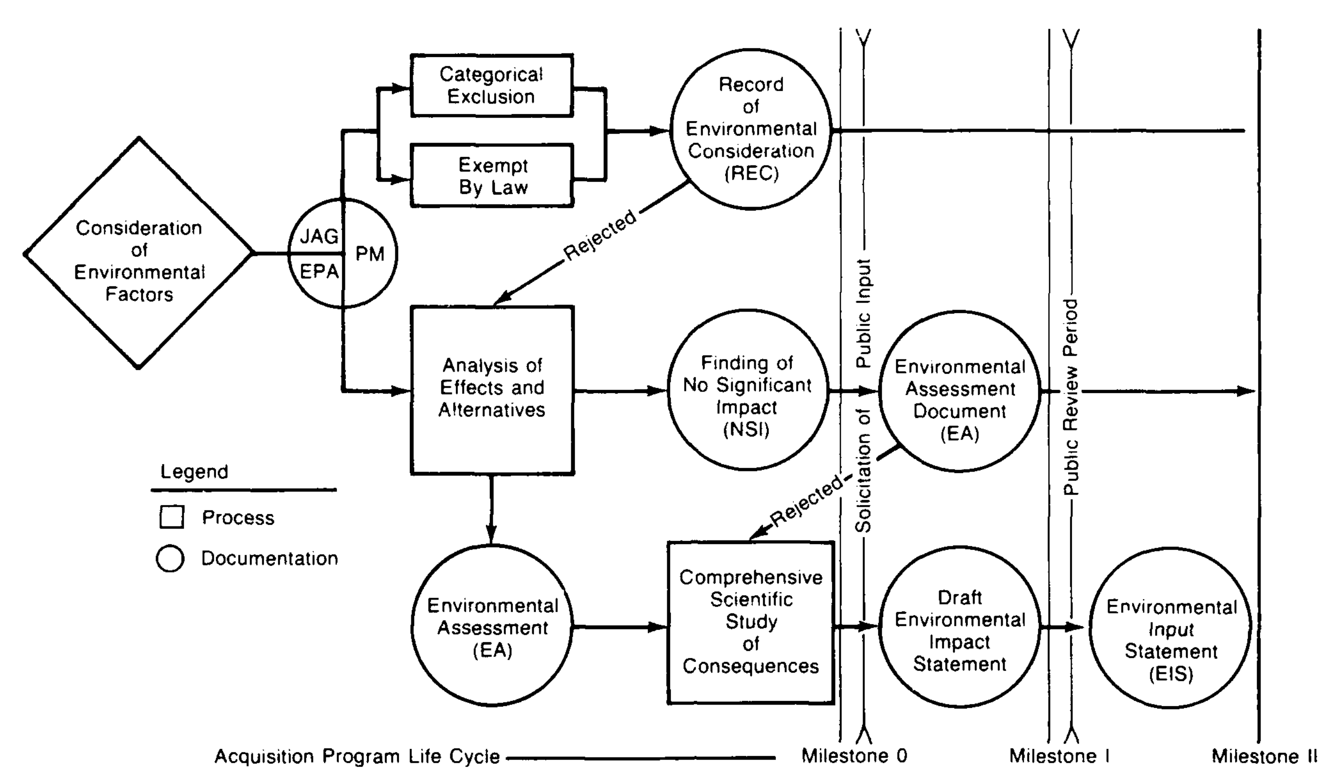
Environmental law hasn't changed the program manager's mission. It is your duty to develop and produce a component system for the best possible deterrent force in the world. The environment is a component of that task, and when you make a commitment you are on the way to meeting legal requirements and are using good engineering judgment.

Legal Obligation

There are two types of environmental laws. At this writing there are 53 substantive laws, those that specifically forbid certain activities or use of materials, or limit the amount of pollutants that may be discharged into the air, water or land. There is one procedural law, the National Environmental Policy Act (NEPA), which the program manager, as designated proponent for new systems, is legally obligated to comply with.

The NEPA requirements begin at a program's earliest planning stages and obligate the program office to consider effects of the program on the global environment. This can be a part of the long-range logistical plan, accounting for costs of handling, storing, transporting, and disposing of materials. However, it should go beyond the usual consideration of these factors as part of a military system, and comment on the effect of removing these materials from their natural confinement (like a mine), effects on geographical areas and people in-

FIGURE 1. SUMMARY OF ENVIRONMENTAL ANALYSES AND REQUIRED DOCUMENTATION



volved in the manufacturing, and ultimate effect on the environment after materials are disposed of. Environmental aspects of the logistical planning must be published in a separate document called an environmental assessment (EA).

The EA is subject to review by representatives from affected communities. The best approach is to solicit public review and invite comments from local governments, environmental groups and citizen committees. This is not always possible with military programs. If there are good, overriding reasons in the interest of national security, review groups can be limited to "cleared" individuals. The necessity to conduct and publish an environmental assessment may add individuals with "need-to-know" status. Security does *not* exempt a program from the obligation to comply with NEPA. Executive Order 12088 has directed all federal programs to comply with environmental laws and only the President may grant an exemption.

The EA is a relatively simple document of 25-150 pages, depending on program complexity. It can be handled by your staff, an installation environmental or engineering services office, on an interagency agreement by another Service, or contracted to a firm specializing in environmental studies. It must be done during the concept exploration stage of the program life cycle and is a requirement for Milestone O. A good, legally sound EA usually takes 2-3 months to complete, in addition to administrative time associated with contracting out if you opt for it. Samples of good EAs are available at most post or headquarters environmental coordinators' offices. However, I highly recommend that at least one person of responsibility on the program staff be a graduate of one of the training programs that all Services offer.

The EA can conclude with a finding of no significant impact (NSI) in which case the matter is closed and the program can proceed. If the finding is contested, it can go through a review process to the Council on Environmental Quality, a presidential board, for final determination.

Most EAs will lead to a finding of some impact sometime in the program life cycle. This necessitates filing an environmental impact statement (EIS), a complex document with details of the interactions of materials on specific locations and communities. The EIS is developed during the concept demonstration/validation phase and a draft EIS is submitted as part of Milestone I requirements. The EIS considers alternatives and trade-offs, and except for extreme security risks it is a public document allowing public participation in the acquistion process.

Let me stress that public participation does not imply public control. The EIS may be negative in the results expected. It states you have considered all courses of action and are taking the best available based on latest scientific evidence. Alternatives may cost too much in both dollars and/or vulnerability to threats and, therefore, the country may *have* to live with the program's environmentally unpleasant results. The EIS alerts the public about how you plan to deal with problems, and that you know what the military may face. Failure to comply with NEPA and file required documentation is an abrogation of your responsibility and gives control to the public, perhaps irretrievably.

***Toxins, the Real Enemy**...Fixing responsibility for past mistakes and for the changeover to a new way of doing things will not be easy.*

ENVIRONMENTAL POLICY FOR PROGRAM MANAGERS

Program Start	—Document Environmental Consideration
Milestone 0	—File Environmental Assessment
Milestone I	—Draft Environmental Impact Statement
Milestone II	—Environmental Impact Statement Filed
Milestone III	—Amendments to EIS based on Manufacturers Input
Milestone IV	—Supplement to EIS to Reflect New Technology, New Applications of System
Milestone V	—EIS for New Projects, Changes Generated by Better Disposal Technology or Mandated by New Laws or Treaties

Finalization of the EIS may occur throughout the full-scale development stage, when scientific research may be a part of the alternative consideration. The EIS is finalized and submitted as part of Milestone II and represents a legal commitment. The program must adhere to tenets outlined in the EIS up to and including disposal, unless an amendment is filed.

Ethical Obligation

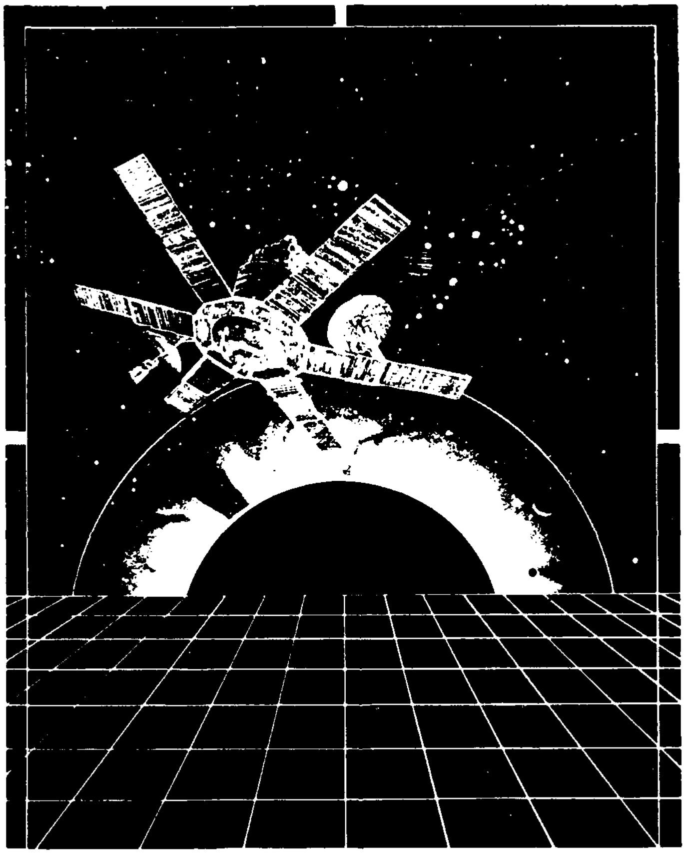
Compliance with NEPA fulfills the program manager's legal obligations. Failure to comply can, and will, delay or stop your program; increase your life-cycle cost; and diminish effectiveness of your system. Compliance with NEPA is a mechanism for meeting your ethical obligation to produce a product meeting requirements of substantive laws. Your product must be manufactured by people in factories that are parts of communities. Equipment must be operated by personnel you have an obligation to protect, and deployed by commanders who must comply with myriad local, State and federal regulations. Failure to comply with substantive environmental laws can bring fines, jail sentences and ruined careers.

The program manager exercises far-reaching, long-term control and, possibly, can contribute more to the quality of life in the military environment than any other person.

Mr. Williams was a Visiting Research Fellow in the Department of Research and Information at DSMC from July-December 1988 as a portion of a 1-year Executive Potential Training Program. He has returned to duties as a Research Chemist with the Bureau of Engraving and Printing, U.S. Department of the Treasury.

ACQUIRING THE STRATEGIC
DEFENSE SYSTEM ENGINEER

Captain John J. Donegan, Jr., USN
Colonel Nicholas W. Kuzemka, USAF



SSGT Lowell Gilstrap, USAF

The Strategic Defense Initiative (SDI) program is considered to be one of the most complex management and technological challenges in history. The Apollo moon landing program and the Manhattan Atomic project had an unequivocal national mandate, whereas the SDI program has been under extensive scrutiny, especially political, since the President's speech in March 1983. Significant technological progress has been made and it is increasingly apparent that our goals vis-a-vis the SDI program may be attainable.

The techniques and procedures used to acquire the Strategic Defense System Engineer provide an excellent case study for program managers. This is especially so when dealing with a complex program involving numerous acquisition organizations. Thorough planning was essential and extensive efforts were taken to use lessons learned from other programs and then carefully tailor the acquisition approach to meet Strategic Defense needs.

The key is to integrate technology efforts to verify that the Strategic Defense System (SDS) will meet national requirements. This is being done through the SDS Demonstration/Validation Program or Phase I DEMVAL program. The Strategic Defense System Engineer is critical for this effort. Planning, acquisition strategy, and selecting the system engineer had to be done thoroughly and in a timely manner. Business as usual was not acceptable and many streamlined acquisition techniques and innovative approaches, to meet legal requirements, were applied. Many approaches recommended by high-level acquisition review groups were used. Most importantly, it was a tremendous team effort among the Strategic Defense Initiative Organization (SDIO), military services, Department of Defense (DOD) agencies and industry.

The authors, the SDS Phase I program manager and the head of SDIO contracts brought the effort together with the assistance of many capable and dedicated people. For program managers and others in the acquisition profession, there is much to learn and share from this experience.

Introduction

Design and integration of the Strategic Defense System is a major task impacting organizations conducting Strategic Defense Initiative research, or assigned responsibility for research and development of one of the elements to meet system requirements. Requirements for the system engineering and integration (SE&I) or System Engineer effort are

shown in Figure 1. The role of the System Engineer and the selection of the System Engineer was important to both government and defense industry organizations. An acquisition strategy was needed to balance requirements for engineering and integration with an understanding of the concerns of the military services and which would set ground rules for SDIO contractors. The acquisition strategy had to provide for a changing program, both technologically and politically. The acquisition process needed to capture work requirements and conditions central to performing the system engineering task. This had to be done in a short time, using streamlined acquisition techniques and procedures. Innovative approaches and streamlining enabled the job to be done thoroughly and in about one-half the time normally required for such an effort. The schedule is shown in Figure 2.

FIGURE 1. SE&I REQUIREMENT

- Developing the overall integrated Phase I system design
- Coordinating integration and interface requirements among
  - Prime element contractors
  - Service element program managers
- Planning and supporting integrated testing
  - Managing test resources
  - Evaluating system performance
- Performing SDS system engineering
- Establishing effective communication channels
- Planning and managing program schedules and cost
- Providing engineering guidance to program participants
- Designing the battle management functions
  - Evaluating and coordinating ongoing BM experiments
  - Designing command and control and integrated EV (industry-coordinated specification)
  - Selecting algorithms, network concepts, processors, and software

FIGURE 2. SE&I ACQUISITION SCHEDULE

. ACQUISITION STRATEGY	JULY-AUG. 1987
. DAB REVIEW	8 JULY 1987
. OCI MEETINGS	LATE AUG.-EARLY SEPT. 1987
. SOW PREPARATION	AUG.-DEC. (4 SDI-SERVICE CONFERENCES)
. RFP PREPARATION	NOV.-JAN. 1987
.. DRAFT TO SERVICES & INDUSTRY	23 DEC. 1987
.. COMMENTS RECEIVED	11 JAN. 1988
. RFP RELEASED	29 JAN. 1988
. BIDDERS CONFERENCE	11 FEB. 1988
. PROPOSALS RECEIVED	21 MARCH 1988
. CONTRACT AWARD	12 MAY 1988

Background

In a speech on March 23, 1983, President Ronald Reagan challenged the nation to use technology to achieve a defensive capability that would erase the Soviet ballistic missile threat. The President's speech highlighted the following:

> ...I call upon the scientific community who gave us nuclear weapons to turn their great talents to the cause of mankind and world peace: to give us the means of rendering these nuclear weapons impotent and obsolete...I am directing a comprehensive and intensive effort to define a long-term research and development program to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear missiles.

His speech gave impetus to critical events and activities influencing conditions surrounding the acquisition of a system engineer in the fall of 1987.

President Reagan gave new direction to the U.S. strategic defense research effort and provided an environment for studying and organizing an approach which shifted the emphasis from offense-dominated deterrence to a strategic equation in which defenses would play an ever-increasing role.

President Reagan's directions were implemented in National Security Study Directive (NSSD) 85, "Eliminating the Threat from Ballistic Missiles," which called for two studies. These studies, further defined in NSSD 6-83, "Defense Against Ballistic Missiles," April 1983, established the Defense Technologies Study Group, headed by James Fletcher, to undertake technical evaluation of the feasibility of defenses and the Future Security Strategy Study (FS3), headed by Fred Hoffman, to assess political and strategic implications. The Fletcher and Hoffman Reports were finished by October 1983. The Fletcher report took "an optimistic view of new emerging technologies" and reported a "robust multitiered Ballistic Missile Defense (BMD) system can eventually be made to work." The administration's position emerged as a recommendation that the United States embark on early demonstrations of BMD technologies.

National Security Decision Directive 119, Jan. 6, 1984, set guidelines for BMD research and established the Strategic Defense Initiative. It embraced the concept of phased deployment of an evolutionary Strategic Defense System, and set goals for transition from an offensive to defensive deterrence, the ultimate elimination of ballistic missiles, a hedge against any near-term expansion of the Soviet ABM capability, and provided an incentive to the Soviet Union to agree to deep, equitable and verifiable reductions of nuclear forces. More specifically, the directive called for "initiation of a focused program to demonstrate the technical feasibility of enhancing deterrence and thereby reducing the risk of nuclear war through greater reliance on defensive strategic capability."

The Fletcher and Hoffman Reports and the Eastport Report (completed in 1985) provided key guidance to SDI and led to formalization of the Strategic Defense Initiative in the form of a charter for the Strategic Defense Initiative Organization (SDIO). The charter spelled out in DOD Directive 5141.5 on Feb. 21, 1986, described the mission, organization and functions of SDIO.

From 1984 through the spring of 1987, the SDIO conducted many studies of technology, architecture, and battle management, command, control and communications. The SDIO positions on using technologies, like directed energy and kinetic energy weapons, shifted as technology research played an important role in the inclusion, or exclusion, of a particular element in the initial architecture. By spring 1987, the Secretary of Defense concluded that an SDS was probably feasible and that a demonstration/validation program could be structured to support it. This led SDIO to present the program to the Defense Acquisition Board (DAB) for a Milestone I decision. The architecture and system elements—Exoatmospheric Reentry Vehicle Intercept System (ERIS), Boost Phase Surveillance and Tracking System (BSTS), Space-Based Surveillance and Tracking System (SSTS), Space Based Interceptors (SBI), Ground-Based Surveillance and Tracking System (GSTS), Battle Management/Command, Control and Communications (BM/C3) and Advanced Launch System (ALS)—became institutionalized in the *Strategic Defense System Concept Paper (SCP) Volumes I, II, III; the Test and Evaluation Master Plan (TEMP)*, and the *Program Plan*. The ALS was later the subject of joint NASA/AF/SDIO management and a separate DAB. Basic strategy was to provide an evolutionary flexible approach within which technological and budgetary changes could be managed.

Purposes of DAB reviews June 30 and July 8, 1987, were to confirm program readiness for the demonstration/validation phase, connect SDI to the DOD acquisition process, position the program to progress in an orderly manner to a timely and informed full scale development (FSD) decision for the first phase of an evolutionary SDS, and optimize contributions of all organizations working on the SDI Program. As a result of the DAB and subsequent Secretary of Defense approval, a Phase I SDS DEMVAL program was initiated with one key DAB recommendation being to acquire a systems engineering and integration contractor to develop a design from the SCP concept and, subsequently, demonstrate feasibility of the SDS.

Emphasis of the DAB recommendation was on developing a systems approach to SDS and Element DEMVAL efforts and defining information necessary to satisfy requirements for Milestone II. The DEMVAL Program included developing preliminary system specifications, conducting comprehensive experiments, exploring technology, transitioning technology through DEMVAL, and preparing for full-scale engineering development.

In spring 1987, with preparations for the DAB review underway, SDIO was exploring approaches to system engineering and integration. The SDIO researched large system development programs to determine how they used a Systems Engineering and Integration (SE&I) contractor, the acquisition methodology employed, and the cost relative to overall program cost. When the approval, in July 1987, of Milestone I accelerated efforts to define and select an approach for acquiring the system engineer, the SDIO was ready to proceed.

Acquisition Strategy

Before Milestone I approval, which set the stage for finalizing an acquisition strategy for DEMVAL, the SDIO had "franchised" individual SDS element acquisitions to the Army and Air Force. The U.S. Army Strategic Defense Command and the U.S. Air Force Systems Command received acquisition guidance and funding via work package directives (WPDs) from the SDIO through parent service headquarters to establish contracts for these elements. These contracts were, in most cases, competed by the Space Division or the Electronic Systems Divisions of the Air Force or the Strategic Defense Command of the Army and were proceeding on separate schedules. The military services arranged for system engineering and integration within the elements for which they had responsibility.

To provide a "systems approach" to development of the elements that comprise the SDS, requires a system-level integration contractor. Due to the advanced stage of work underway by

the military services on some elements, it was apparent that if system engineering at the SDIO level was additive to the Services' Integration efforts, then the contractor's role could become one of an "integrator of integrators," resulting in a layered and inefficient approach. This approach was rejected in favor of a single contractor to accomplish the SDS system engineering, and integration at SDIO and Service levels. The SDIO defined the contractor's role as ensuring system performance as required by the Joint Chiefs of Staff (JCS). This entailed providing threat analysis, results convergence, requirements analysis, interface management (between elements), system design and management. The contractor would be required to assist with managing the SDS DEMVAL effort including secure Management Information Systems (MIS), communications and operations for information storage and retrieval.

Since each element of the SDS posed different, but often related, technical challenges, the single-contractor approach develops requirements, establishes interfaces and relationships within an acceptable high-level SDS architecture. This approach sought to influence each element to evolve less as a stand-alone capability, and more as one responsive to needs of the United States Space Command and requirements of the Joint Chiefs of Staff. Although user policy was evolving with SDS requirements, the effort to clarify the threat to a specification had been proceeding with various SDS architectures. Initiatives on threat and architectural definitions had been undertaken by organizations including federally funded research and development centers (not-for-profit institutes), universities and industries.

Another issue complicating acquisition of the system engineer was the decision to task that contractor with major battle management/communications, command and control (BM/C3) design responsibilities. The BM/C3 represented interfaces among all elements and its development was considered an integral function of system engineering and integration (SE&I) responsibilities. This decision, on the other hand, increased potential for organizational conflict of interest on issues involving hardware preferences.

FIGURE 3. OCI

- Applies to prime
- Subcontractors may be restricted
  - Segregation of work
  - Government review/decision
- Offeror's OCI statement should lay out
  - Possible conflicts
  - Proposed actions to comply with OCI provisions
  - Anticipated waiver requirements
- BM/C3 requires industry coordinated specifications
- Evaluation
  - Possible conflicts must be resolved to satisfaction of SDIO
  - Proposed resolutions will be evaluated by SDIO General Counsel

Organizational Conflict of Interest (OCI) and Competition

Developing a competitive environment for acquisition of a system engineer centered on eliminating organizational conflict of interest while preserving competition. Since many U.S. corporations with large-scale systems engineering expertise were already involved in SDIO contracts, careful guidelines were required. Primarily, these guidelines were managing the issue, definition of requirement, actual conflicts and perception of conflicts. The process of developing OCI guidelines was key to finalizing acquisition strategy and every effort was made to consider all approaches. The OCI process began early, but a final decision in wording was not ready until 2 weeks before release of the Request for Proposal (RFP).

Meetings initially were with organizations experienced in major system integration to develop an understanding of the system engineer role and OCI issues. Discussions of OCI issues involved a widening group of SDIO, government agencies and potential contractors during June-July 1987, in conjunction with discussing the system engineer role in the DEMVAL program. Near the end of July 1987, OCI issues and the system engineer role began to crystallize. The *Commerce Business Daily* announcement and initial "strawman" OCI clause were prepared.

In August 1987, key contractors and potential offerors were invited to meet with SDIO to discuss the system engineer role, including OCI issues. Meetings in late August and September 1987 included General Electric, IBM, Science Applications International Corporation, Rockwell International Corporation, TRW, Inc., Martin Marietta, Inc., McDonnell Douglas Astronautics Company, and General Dynamics Corporation.

Industry views on OCI were as diverse as those of the government. Several favored a restrictive OCI approach which excluded prime and major subcontractors on all Phase I SDS elements. Others emphasized perceived vs. actual conflicts, exclusion of national test bed (NTB) contractor, restrictions to scope of work at high-

level, and case-by-case restrictions for lower-level work.

Inclusions of BM/C3 responsibility produced many opinions. Some companies favored combining SE and BM/C3 functions. Others proposed approaches where the system engineer contractor covered just system engineering, expanding the SE and BM/C3 role to each element. Another suggested a new company to "fence" the system engineer project. One suggested an element prime could "manage" the conflict of interest and preserve experience continuity within the program. Several believed a hardware exclusion was inevitable.

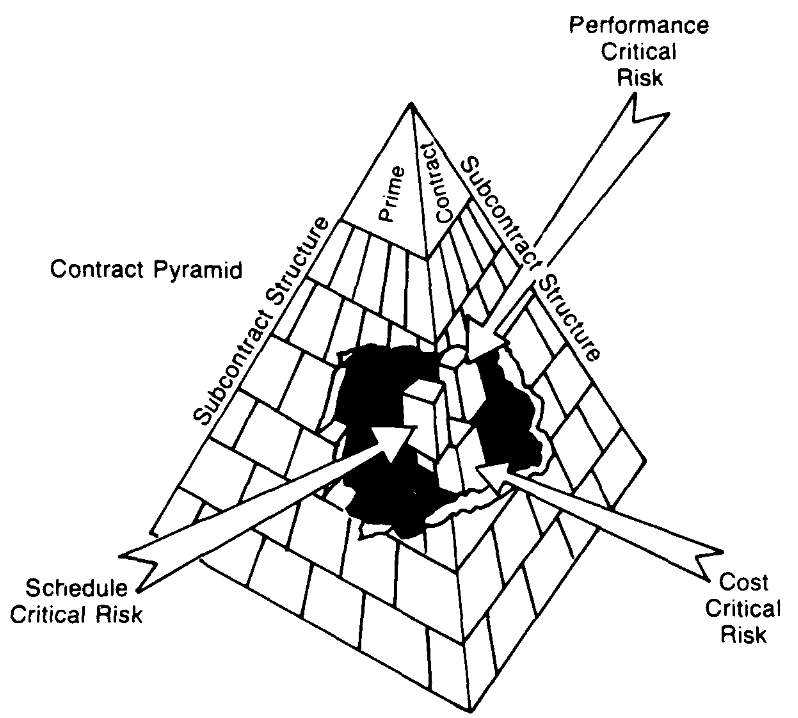
During September-October 1987, OCI options were developed. Follow-up meetings to discuss options were held with the military services during the SDIO Contracting Agents Conference, and OCI was covered as part of the acquisition plan briefing. The OCI position was discussed at a meeting of field organizations to prepare the system engineer request for proposal.

Final version of the OCI clause was completed in December 1987 and released in the *Commerce Business Daily* on Dec. 23, 1987. Figure 3 highlights select features of the OCI clause. In summary, the OCI clause excluded Phase I element prime contractors and the National Test Bed (NTB) prime contractor. They could, however, perform as subcontractors provided they were not in a position of making design/development decisions relating to equipment or systems they provide. For the Battle Management design, the SE&I contractor was to develop an industry coordinated specification to provide future full and open competition. The OCI was approved by the SDIO Director, Lieutenant General James Abrahamson, USAF, on Jan. 23, 1988, and presented at the bidders conference Feb. 11, 1988.

Setting Goals for Acquisition Strategy

Primary objective of the acquisition strategy was to foster innovation by setting goals to balance government business values and technology values.

FIGURE 4. OBSCURED RISKS



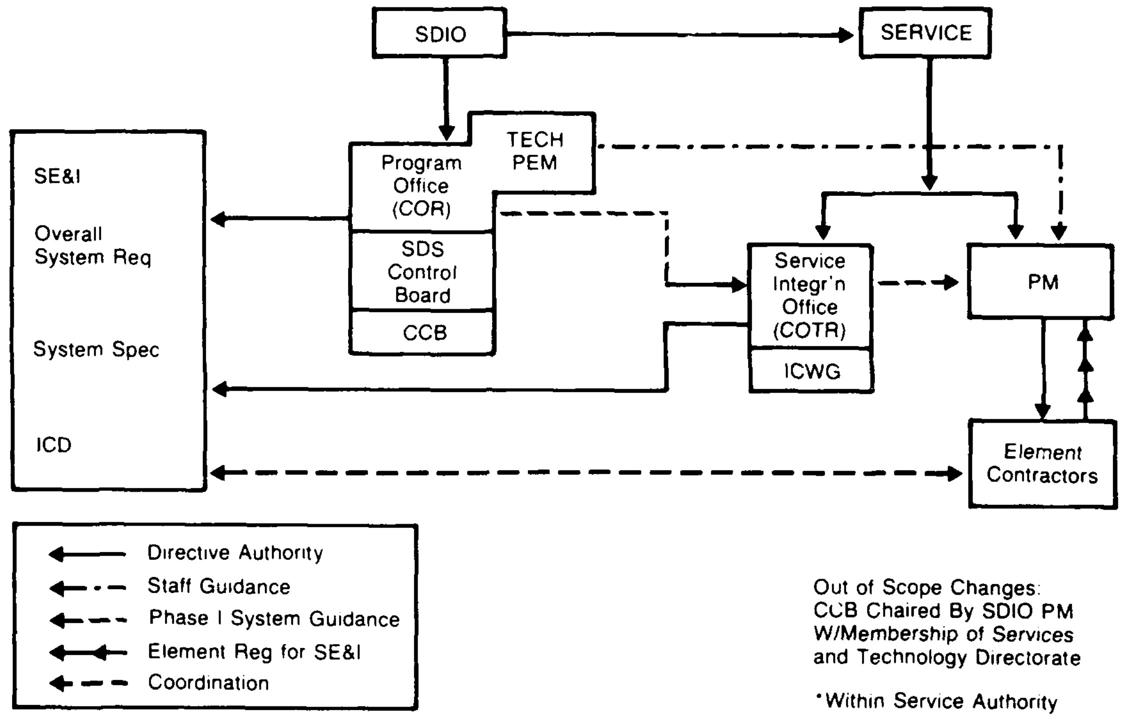
Much early success of the SDI Program was attributed to industry innovation, and it was essential for this to continue for the Phase I SE&I Program, becoming a key part of acquisition strategy. There was a priority emphasis on promoting small business by opening the SDS program to innovation from small and small-disadvantaged companies. Strategy had to be designed to avoid development and production problems, treat contract management as playing a major role in SDI program management, provide flexibility, and be structured to provide a broad-based effort at all levels to achieve objectives and values.

System program management must consider contract management by focusing on prime-contractor results, issues, and priorities; incentives built into contract terms; management information systems; and risk issues. The risk area, especially obscured risks like performance, schedule and cost, would allow program management to focus on program aspects before they are problems (Figure 4). This is especially important for the system engineer because many organizations and elements are involved and open effective communications are essential.

The objective was to control critical system activities, events and items by structuring contract terms and conditions to achieve necessary visibilities, controlling risk situations as they occurred.

Management of critical issues would focus risk management on those issues and set priorities. It would be characterized by rewarding innovation and risk-taking, flow-down of incentives, and positive and visible control of risk. This would keep the bottom-end of the contract pyramid dynamic and work in tandem with streamlining the reporting process.

FIGURE 5. SE&I MANAGEMENT



A single system integrator was needed to operate across all elements. This would avoid difficulties of integrating between Services and eliminate the requirement for an integrator of integrators. The single integrator would not eliminate the need for integration by the Services within their element contractors. To enhance the integration process, the Services designated system integration program managers (SIPMs) who worked through an SDS Control Board to resolve integration issues quickly and establish SDS integration policy (See Figure 5). The SIPM role, key to success of the SE and I effort, has kept the Army and Air Force actively involved with overall SE and I program management.

Many BM/C3 issues intertwined with system-wide considerations. Moreover, critical aspects of BM/C3, like software, had to be developed in conjunction with system architecture.

The contract was established for a 5-year with 2 additional 2-year options. A special termination cost clause was incorporated to provide the contractor confidence and incentive to make long-term commitments to the program with the assurance that the government would recognize those costs in the event of termination for convenience. There was priority emphasis on opening the SDS program to innovation from small disadvantaged companies.

Development of Statement of Work And Request for Proposals

The SDIO program manager with assistance from a support contractor, RJO Enterprises, Inc., initiated the system engineering and integration statement of work July 12, 1987. During the next 8 months, RJO supported SDIO with an intense effort to capture program goals and philosophies of SDIO, the Services and other agencies and build them into the statement of work (SOW). The SOW detailed requirements for the system engineer and ensured SDIO and the Services that tasks of system engineering and integration were adequately addressed in the final document and included inputs to the Request for Proposal and the contract data requirements list (CDRL).

Developing Detailed Road Map and Schedule

Several factors necessitated guidelines and timeliness to be developed, and agreed to, for the contract definition process. The complex nature of the management structure and acquisition environment involving SDIO, the Services and contractors required formal coordination procedures. Emerging technologies and evolving requirements for a potential SDS needed inputs and exchanges of technical information as the SOW was documented. Timeliness and current requirements for SDS elements in development required proper definition, timing, and sequencing of system engineer activities. Consequently, the SOW staff developed a detailed road map of contract definition activities using computer-aided network analysis and scheduling techniques.

Process for Drafting SOW

Survey Process. Before writing SOW, other acquisition programs were researched for mistakes made or avoided. Similar programs (NASA Space Station) and different programs (FAA National Air Traffic Control upgrade) were reviewed.

Scoping Program. Initially, two SOWs were proposed. One addressed system engineer work by the winning offeror. The other was directed toward a contractor to perform development work for the battle management/command, control, and communications architecture, software, and hardware. This reinforced the earlier decision to have the system engineer and integrator serve as the prime for BM/C3 development because, as the process continued, the Services saw the danger of one contractor performing the system engineer function while a second contractor developed the BM/C3 element. The chief problem was that BM/C3, in effect, was operational coordinator of the other SDS elements; i.e., it commands and controls tasks determining timing and sequencing of commands to the system's sensors and weapons. The contractor developing BM/C3 architecture should have the best understanding of how to allocate overall system functions.

Describing Work to be Done. The SOW drafters determined the degree of detail and the work to be done by the system engineer. There were two views. One favored general recital of contractor responsibilities; e.g., the SOW would explain how to perform cost analysis, develop functional requirements, and how to report results using tailored data item descriptions (DIDs). It would leave the contractor latitude regarding approach, scope and content. The second view prevailed and added specificity in the SOW. This often was done at the insistence of participants (particularly Services and specialized agencies) with proprietary interest in specific technical areas. The BM/C3 section of the statement of work was written in the same manner. Attention given "how to" and "what to" was achieved by an interactive process meeting Services' desires without tying the system engineer's hands.

Key System Engineering Activities

The SDIO reviewed key SDS program documents, like system concept paper and baseline concept document, and knew initially that two sets of system engineering tasks were uniquely critical. One was developing an allocated functional baseline by a formal system requirements analysis. The other was a comprehensive analysis of requirements and impacts of system survivability and security.

System Requirements Analysis. One result of close interrelationships among SDIO, Services, and contractors was developing an SDIO standard for SDS system requirements analysis (SRA). It was derived from a standard (BMO 77-6A) developed by the Air Force Systems Command Ballistic Missile Office (BMO) with modifications appropriate to SDI. This document illuminates a rigorous process for identifying system functional requirements and allocating them to specific SDS elements (BM/C3, weapons, and sensors).

Much effort was used tailoring the BMO standard. A significant task was breaking down SRA steps into procedures that could be applied across the system. The standard had to show several elements would operate independently as well as in conjunction. Each element was a system, yet must depend upon other elements (sometimes also operating independently) to perform within the system-of-systems called SDS. The Services had differences in perceptions of operational roles of their elements and there was ambiguity regarding SDS requirements. There were spirited exchanges when trying to reach acceptable language for the contractor's role in developing functional requirements.

Several rounds of coordination were required before the SRA draft standard was approved for SOW inclusion. Divergent goals and requirements of each Service made thorough coordination vital. The process was beneficial for everyone and yielded a greater understanding of the requirements definition process, and a coordinated SRA standard.

Survivability and Security. Disciplines of survivability/vulnerability and system security engineering are separate entities in the pantheon of technical engineering specialties. Survivability implies that, during and after being subjected to hostile man-made environments, the system will complete the required mission. Security implies protection of system assets or information from damage or compromise, in peacetime or conflict. They have a common objective: to ensure the system performs during hostile action, regardless of source. Since survivability and security can be affected by decisions made early in the development process, comprehensive language was invited to ensure these disciplines would be included in the requirements definition and design verification analysis.

Key Players

While writing and coordinating the statement of work, SDIO depended upon experiences of organizations; i.e., the Services, specialized government agencies like the National Security Agency, and contractors. Approximately 40 people were involved. Where group experience fell short, consultants were retained on a short-term basis. Consultants had years of experience in technical program management and injected independent judgments to improve quality.

Service program managers at the U.S. Army Strategic Defense Command, Huntsville, Ala., and the Air Force Systems Command Space Division, Los Angeles, were developing SDS element systems. It was a tremendous team effort and resulted in a coordinated SOW in minimal time.

Dual Element Missions. Some elements are not dedicated solely to the SDS mission. This became apparent with the potential for problems regarding turf and priorities. For example, the Boost Surveillance and Tracking System (BSTS) and the Space-based Surveillance and Tracking System (SSTS) are being developed by the Space Division to support missions apart from SDS. As such, the BSTS Program Office has to ensure it does not develop a system that unacceptably decreases its ability to perform required collateral missions. Hours of drafting, negotiating and redrafting the

SOW were required relative to prioritization and allocation of mission functions, before the issues were resolved.

In November 1987, when the first draft SOW was completed, it was necessary to have an initial meeting of the full group with the Services and National Security Agency (NSA) involved. Service organizations included the Army Strategic Defense Command, Air Force Space Division and Electronic Systems Division. The SOW draft underwent significant changes. The NSA inserted requirements pertinent to computer and communications security. The Army's Strategic Defense Command (SDC) stressed requirements to ensure stability in designs of elements it manages, including Exoatmospheric Re-entry Vehicle Intercept System (ERIS), and the ground-based portion of the BM/C3 element. The Air Force had similar interests. The meeting concerned how much authority the system engineer would have in defining SDS requirements. It was apparent that a middle ground had to be reached where realistic trade-offs and compromises could be made in the autonomy accorded to the Services in developing SDS elements.

Service Inputs. The ongoing SOW process showed philosophical, management, and technical differences among Service organizations. The National Security Agency initially insisted that the SOW specifically address requirements for trusted software, secure systems, and software validation and verification. However, because the DEMVAL program objective was technology demonstration and validation, some NSA requirements were relaxed until the FSD portion of the Phase I effort.

As efforts to align goals within the context of SDS continued, an effective middle ground was established. Wording of the SOW in directing the system engineer to perform functional analysis, or functional requirements allocations, was prefaced with the caveat to recall current capabilities and functions of individual elements. This enabled the system engineer to develop system requirements within realistic constraints, and assured Services allocated baselines would not be changed without traceability to mission requirements.

Combined System Engineer and BM/C3 Tasking. Resolution of whether or not to prepare a single SOW for system engineering and BM/C3 development was that the two efforts were intimately intertwined and must be part of the same procurement. Interweaving the two SOWs was simple after another issue was settled; whether or not the BM/C3 should be considered an element, or should be distributed among existing elements. It became clear that unless it was considered a separate element, overseeing the Battle Management and C3 configurations would be extremely difficult. It was decided that battle management/command and control, and the communications function would be developed as a separate distributed element whose functional requirements, designs, and configuration would be overseen by the Configuration Control Board.

Authority of System Engineer. Agreement was reached on describing position, responsibility, and authority of the system engineer. One viewpoint favored broad authority; the other, a weak, diffused role. The consensus was that the system engineer should be given wide authority through the approval mechanism of the Configuration Control Board. This Board provides representation from the Services and allows them to express preferences or, at least, compromise positions as developed for each prospective change in the system or element configuration in the SOW. The system engineer is responsible for overall system performance.

Remainder of RFP

The statement of work required the most effort, but the balance of the RFP was equally important. Much of which was being written as SOW tasks were defined.

Contract Data Requirements List. There were difficulties in preparing the CDRL, not at first, but near the end. As descriptions of required data items evolved and referenced in the SOW, subsequent changes to that document caused perturbations in data items. Often, a change in a SOW task would call for several changes in data requirements. These changes could be delivery dates, paragraph references, or the descriptions used to prescribe format and content for data items. Much work was involved to gather standard DIDs and tailor them to suit particular program needs. Care was taken in preparing the CDRL with full knowledge that this RFP section would receive less scrutiny in the review process than the SOW.

Rest of RFP. The remainder of the Request for Proposal was prepared primarily by acquisition experts at SDIO with extensive support from the Army and Air Force. Two sections required interaction between engineers and procurement specialists. These were the Instructions to Offerors (ITO, Section L) and Evaluation Factors for Award (Section M). A disconnect between these sections and the SOW could have caused irreparable damage in later stages of acquisition. Because of this coordinated activity, a consistent set of evaluation guidelines was developed for offerors. These two sections led to writing evaluation standards which would be used by the Source Selection Evaluation Board to judge quality of proposals.

Final Coordination Step. When the draft RFP was finished, it was coordinated with the Services and distributed to defense industry contractors who might submit proposals, as primes or as subcontractors. Industry comments improved quality of work performed by the Services and the SDIO acquisition support contractor. Near completion, there were a few minor surprises. Interacting with key people, SOW drafters got the RFP written, coordinated, published and distributed on schedule. This led to an open procurement and exceptional communication.

Selection of System Engineer Contractor

Developing Source Selection Standards. Because of complex interrelationships among military services and supporting contractors, the SDS program manager wanted interested parties to be adequately represented in developing requirements and specifications for an integrated SDS. This ap-

plied particularly to the Services responsible for technology demonstration and validation of the individual elements, and their performances in a total system context. It was necessary to obtain, in preparing evaluation standards, cooperation and input from all participants like that achieved in the SOW preparation.

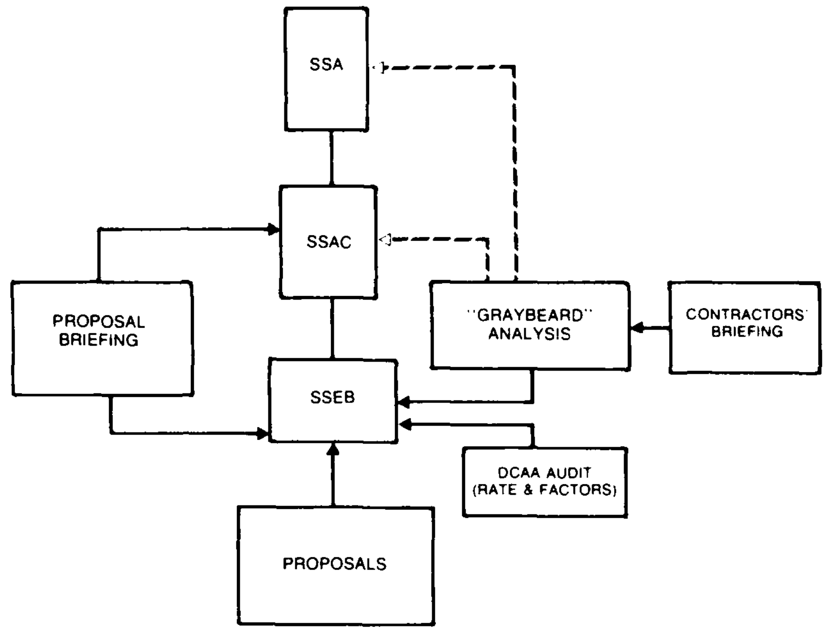
Ideally, standards for evaluation of proposals should be prepared by personnel actually performing the evaluation. However, the accelerated schedule for contract award required that "strawman" standards be composed beforehand. The SDIO developed ground rules and framework for standards development by reference to RFP Section M, "Evaluation Factors for Award"; and Attachment 6, "Instructions to Offerors (ITO)." The ITO established scope of evaluation standards because it prescribes content of the offeror's proposals. Section M describes evaluation criteria and the areas, subdivided into items, to be evaluated.

The SDS program manager, and Service participants, wanted the selected contractor to have a thorough understanding of risks associated with developing a system in an evolving technology environment; i.e., concurrent development of system and technologies required to enhance system performance. The SDIO was convinced traditional techniques of program management and system integration would be inadequate and that innovative approaches would be required. Accordingly, SDIO developed "strawman" standards, based upon the following evaluation criteria: compliance with SOW requirements in a way demonstrating understanding and proper assessment of program risks; soundness of proposed approach; and practical innovation of proposed approach. The third criterion proved most difficult to evaluate in an objective manner.

Section M divided the evaluation effort into four areas: technical, management, sample problem, and cost. Each was subdivided into items to systematize the evaluation process and assign evaluators according to specialties. Items, therefore, conformed to functional or technical categories and paralleled a SOW breakdown. Sometimes, items were further divided into sub-items to write explicit and assessable standards. In preparing "strawman" evaluation standards, SDIO provided a matrix of evaluation items/sub-items vs. evaluation criteria, and assigned selected personnel to write individual first-draft standards. These standards represented minimum requirements to achieve a satisfactory ("green") rating for each item or sub-item vs. each evaluation criterion.

Service representatives and program participants met to review and rewrite or approve the "strawman" package. Technical, management, cost panels, and their panel chairmen, were designated. To give evaluators maximum latitude, panel chairmen were empowered to rewrite or consolidate subitems and standards. Only items and evaluation criteria, having been published in RFP Section M, were fixed. The result provided through the first draft criteria package, a sound basis to approve, modify or rewrite evaluation standards faster. Results were prepared as a final evaluation criteria package, which was provided to each member of the Source Selection Evaluation Board (SSEB).

FIGURE 6. SE&I SOURCE SELECTION DATA FLOW

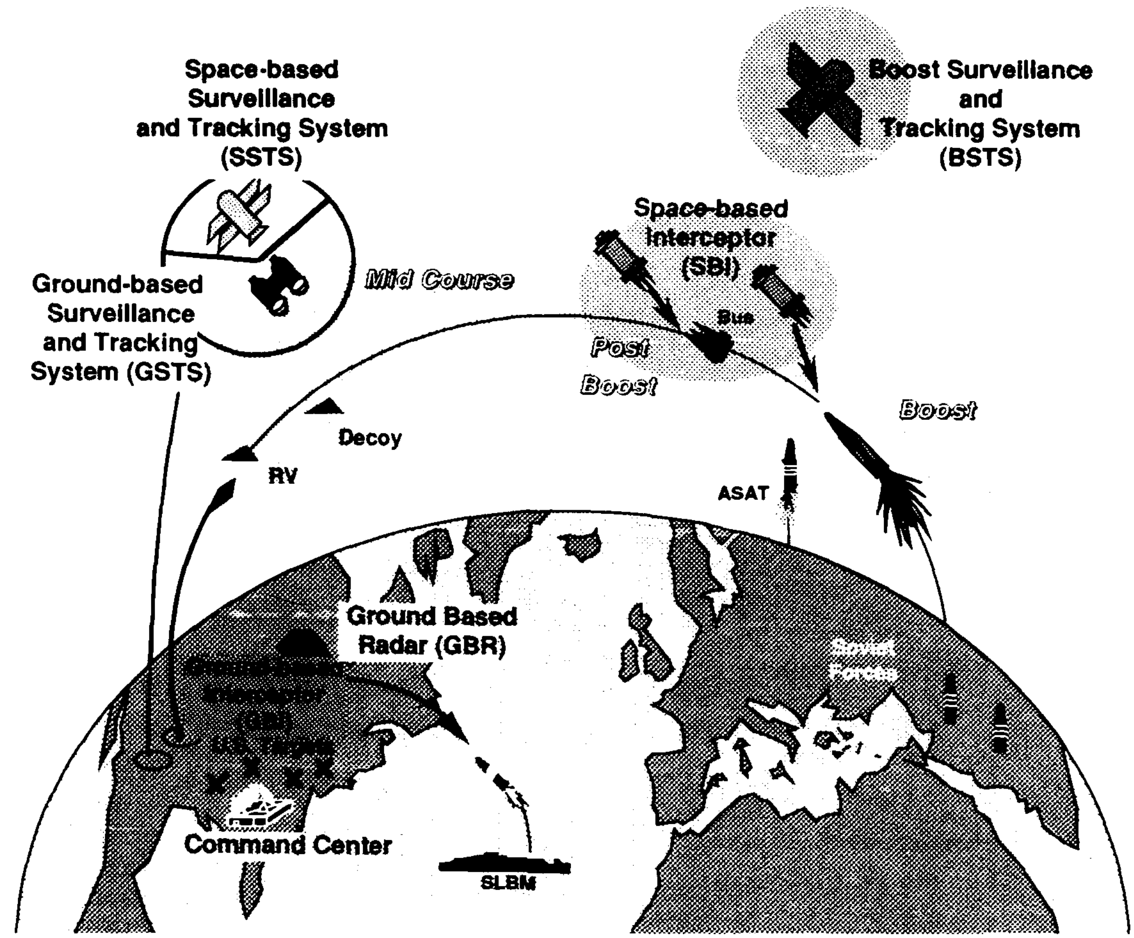


The Source Selection

As a result of thorough preparation for source selection, and a fast decision process with key decision-makers, the actual proposal evaluation and final selection took less than 60 days. Source selection data flow, shown in Figure 6, ensured a closed loop system providing information to the source selection authority and resulted in a well-executed source selection. A decision was made to minimize contractor inquiries (CIs), minimize "leveling" and save time.

The highly experienced and dedicated Source Selection Advisory Council (SSAC) included general/flag officers and members of the Senior Executive Service (SES). The source selection authority used a "graybeard" panel of senior acquisition-experienced management personnel to provide assessments to the SSAC and SSA after meeting with each offeror. For this source selection, the use of the graybeard panel was very successful. There were only two offerors and the individual panel members reported their impressions based on face-to-face meetings. The use of such a panel should be carefully considered. If the panel is to advise the SSA, then it may be better not to expose the SSAC to

THE STRATEGIC DEFENSE SYSTEM



their views or do so only after the SSEB and SSAC have completed evaluations based on formal source selection criteria. The graybeard assessments were done independently of the Source Selection Evaluation Board and solidified the SSAC recommendations. Communications and teamwork between the SSEB and SSAC were exceptional, resulting in a timely decision.

Transitioning to the Contract

Since the system engineer source selection process and eventual contract award to General Electric were fast-paced events and planned without schedule slippage, it was important to have a minimum start-up time, or "quick start," for the selected system engineer team. To quote senior members of the General Electric Staff relative to the start up activities:

> It's like sipping from a fire hose...things are happening so quickly and the volume of activities is so great that it feels like dropping from a train going 80 miles an hour.

Obviously, RFP authors and acquisition participants realized a fast-paced effort would be wasted if the winner could not demonstrate ability to respond to program needs. Of equal importance was the need to have a government and associate contractor apparatus to provide appropriate environment for the system engineer to transition quickly to contract operations.

The system engineer role was dispersed around the nation. Principal locations included Huntsville, Ala., Los Angeles, Colorado Springs, Boston, Washington, D.C., and Philadelphia. It was necessary to establish arrangements to accommodate site oriented transition and Washington-based transition immediately after contract award. This transition was effective immediately after public notification of the contract award via personal visit and telephone conversations. In addition to personal meetings with the director and deputy director, the SDIO staff worked with the GE program manager and the Phase I program manager and staff.

Two major kick-off meetings were held to ensure government and associate contractors could meet with counterparts in the system engineer team, including Phase One Engineering Team (POET) facility in Crystal City. After contract award May 12, 1988, the government sponsored a meeting for less than 2 days (May 17-18, 1988). Key SDIO representatives made presentations to the General Electric senior program staff. Participation by government representatives from SDIO Systems included contracts, technologies and the National Test Bed personnel. Military department system integration program managers made presentations and interfaced with the system engineer. Primary products from the initial meeting were an agenda and an invitation list for a larger system-engineer-sponsored kick-off meeting, May 25-26, 1988, in Valley Forge. This meeting enabled a broader and deeper participation by government and industry, and more program participants bringing the system engineer current information; in turn, the SE could introduce the team in depth, including subcontractors.

The second kick-off meeting examined SDS issues in detail. The key was establishing a single ground rule for dealing with the system engineer by the Phase I program manager, Captain John Donegan, USN:

> The General Electric Company won the system engineer competition...they have proved themselves to the source selection process and they do not need to justify or prove the outcome of the source selection...we need the engineering community working on the design...not rerunning the source selection...we must all work together....

The two "quick start kick-off meetings established precedent for events nationwide and enabled the system engineer to promote constructive relationships at the sites and achieve optimum staff efficiency. The second meeting highlighted presentations by element program managers. It provided working group establishment for important SDS topics including requirements, systems engineering, threats, management information systems and battle management/command and control.

These close and personal interchanges were essential. Working groups provided excellent environments for establishing the most current data interchange in a near real-time fashion.

Summary

From the in-depth review of SE&I requirements to the contract award and the program's "quick start" approach, it is a fact that the acquisition of the SDS system engineer was a success. It can be attributed largely to exceptional teamwork between SDIO, the military services and industry.

A key factor was the fast decision loop process in providing direction and decisions to the program manager and, in turn, to the entire team. The program manager was given authority to execute the program and, whenever needed, higher-level decisions were received within hours. These decisions were based on accurate and timely information, with the program manager having quick direct access to decision-makers. This process saved many months and led to a successful acquisition.

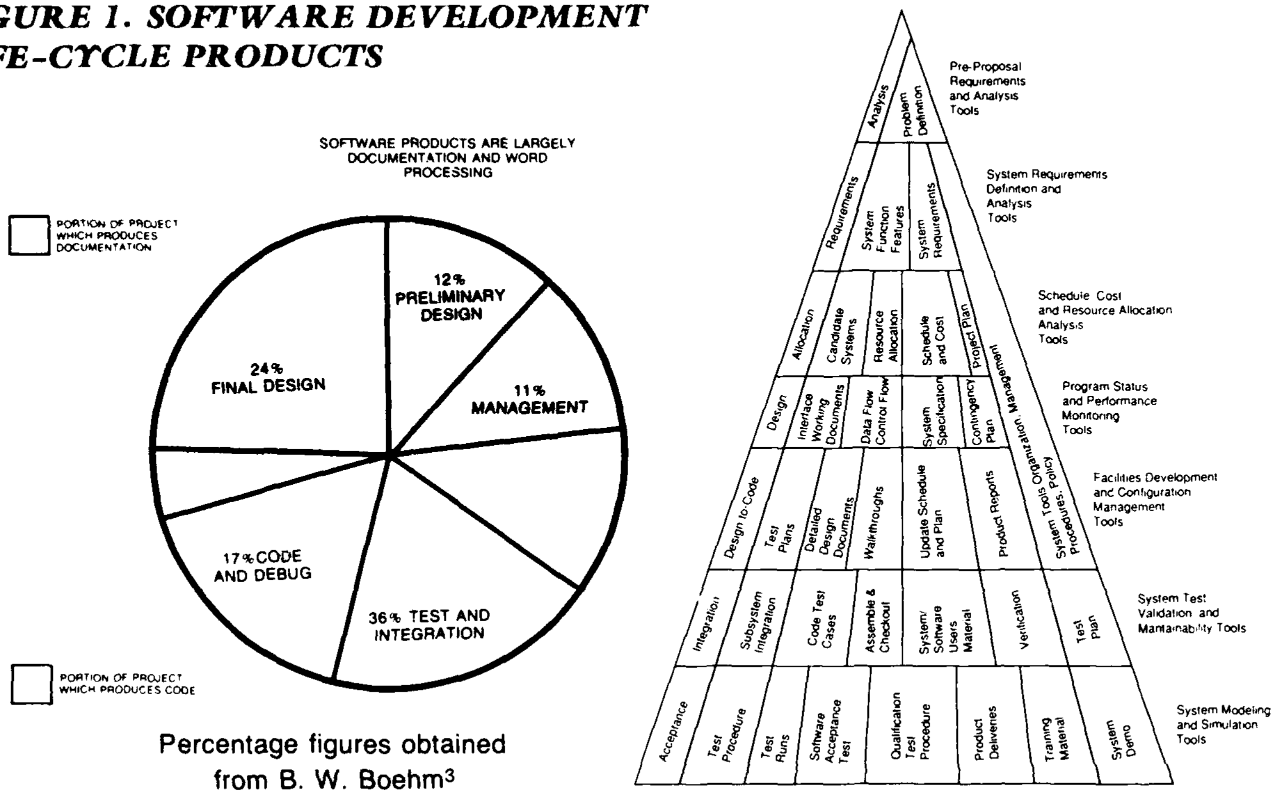
As this article is published, the strategic defense system engineer and integration contract has been underway for 1 year. Minor changes have been made to the contract and statement of work. This should verify that overall acquisition strategy and program planning which sought maximum flexibility in a rapidly changing program, technologically and politically, was basically sound. Additional information on acquisition strategy and contract specifics can be obtained from Captain James Bixler, SDIO/CT, Washington, D.C. 20301-7100.

Captain Donegan is the Program Manager for Phase One of the Strategic Defense System. He has extensive operational experience as a naval engineering officer and has a Ph.D. in Physics. Captain Donegan previously served with the U.S. Navy's AEGIS program.

Colonel Kuzemka is the Director of Contracts and Procurement, Strategic Defense Initiative Organization. He is a member of the Virginia Bar and a certified professional Contracts Manager with more than 25 years of contracting experience, much of it in acquisition and R&D contracting.

IMPROVING SYSTEM/SOFTWARE PRODUCTIVITY

FIGURE 1. SOFTWARE DEVELOPMENT LIFE-CYCLE PRODUCTS



Percentage figures obtained from B. W. Boehm[3]

A prime target for improved Department of Defense (DOD) project productivity is system/software documentation. Development experience provides the following.

"Documentation for large commercial systems software is reputed to be the second highest cost element (behind implementation); for the U.S. Defense Department, it is the most expensive single activity."[1]

As Frank Druding noted in his 1984 DATAMATION article titled, "Looking for the Right Pond," Documentation is a massive, costly, and time-consuming element of software development. It is presently overdone....[2]

What is productivity? How do we measure productivity? Webster defines productivity as the quality or state of being productive; the rate of production. Investment firms will say it's dollar return on investment (ROI). Others define productivity as producing an acceptable quality product at nominal cost; producing the lowest-cost product that does the job. However you may argue the definition, the product has to satisfy the user, and at an agreeable price. The difficulty in evaluating software productivity is the fuzzy concept of *what* is being managed. Typically, software is managed through phased development processes. A common form of productivity measurement is lines of code (LOC) per day/week/year. With so much of the activity being documentation, is this a valid method of assessing productivity?

This paper delves into ways to improve software productivity through streamlining and lightening the documentation burden. Through use of productivity tools and techniques and redefinition of the development cycle, efficiencies are introduced that save great amounts of time, without compromising on quality of the end-product.

Planning for Productivity

A program productivity plan is necessary to define the criteria of acceptance and the approach that will guide the development team. The plan should contain product support tools, criteria for acceptable performance, and an incentive plan to reward diligent and outstanding work.

The need for an incentive scheme is evident by the company's position in the marketplace, the company's standing with regard to competitive awards, and the development organization's performance under contract.

The productivity plan should include development standards and a methodology with established work practices, tools, and qualified-directed workers.

Every team player should feel that each is important and integral to the development effort. This feeling can be con-

TABLE 1. TYPICAL PAPER PRODUCED FOR A DEVELOPMENT PROJECT

ACTIVITY	PAPER PRODUCTS	RESOURCES/TOOLS
Work Breakdown	Structure Charts	CASE Tools
System Requirements	Specifications	CASE Tools
Preliminary Design	Specifications	CASE Tools
Detailed Design	Specifications	CASE Tools
Cost Accounting	Status Reviews	Costing Tools
Milestones	Gantt Charts	Gantt Tools
Schedules	PERT Charts	PERT Tools
Action Items	Summaries	Manpower/Tools
Provisioning/Parts	Reports	Manpower/Tools
Budget/Funding	Plan/Reports	COCOMO Tools
Controls/Procedures	Manuals/Reports	Manpower/Tools
Data Analysis	Reports	Manpower/Tools
SW Development	Plans/Manuals	CASE Tools
Configuration Mgmt.	Plans/Reports	Manpower/Tools
Product Assurance	Plans/Reports	Manpower/Tools
Timing & Sizing	Reports	Manpower/Tools
SW Programs	Listings	Manpower/Tools
New Equipment	Manuals	Manpower/Tools
Training	Plans/Materials	Manpower/Tools
Interface Control	Plans/Reports	Manpower/Tools
Security	Plans/Reports	Manpower/Tools
Test & Support	Plans/Reports	Manpower/Tools
Traceability	Reports	Manpower/Tools
Interproduct	Reports	Manpower/Tools
Studies	Reports	Manpower/Tools
Repair/Spare Parts	Reports	Manpower/Tools
Inventory Control	Reports	Manpower/Tools

* Manpower/Tools = Over two-thirds of total cost of project in terms of man hours to produce deliverable products.

veyed by using a credit/point system that checks all key milestones and activities in the development effort, with accumulated points for milestones met and quality product achievements.

Tools are needed to improve productivity. If developing organizations are evaluated on their performance, it is mandatory that they have tools at least equal to the competition.

Figure 1 depicts software products as largely documentation-related.

The tools necessary to be competitive today are the computer-aided software engineering (CASE) tools used to produce the system hardware, software, and documentation.

Table 1 shows typical products of a development project and the resources used.

Developing Objectives for Productivity

Two sets of objectives should be developed: short range and long range.

Short-Range Objectives

Short-range objectives should establish productivity goals for first phase of the project, identify tools designed to meet these productivity goals, establish measures and evaluation guidelines for determining accomplishments, and document results of any productivity gains by which the acquisition of tools can be justified.

Long-Range Objectives

Long-range objectives should provide upper management with decision tools, provide developers with the environment and the education for increased productivity, establish system/software hardware productivity factors that decrease cost, accelerate the delivery and improve quality of the products.

Project Factors: Complexity Adds to Cost

The productivity plan should consider the complexity of the project. For example:

Classified Projects. Various factors have motivated a more substantial level of investment for improving productivity: project-peculiar demands which often impact schedule and cost; rising cost and scarcity of cleared development personnel; increased demand for quantity and quality of product deliverables; and cost of development tools.

Tempest Requirements. Classified projects require that all work in the development area be Tempest-secure; i.e., void of emitting electronic signals of any nature. This requirement makes it necessary to procure equipment of special construction. This places additional constraints on budget and schedule commitments.

TABLE 2. PROJECT COMPLEXITY FACTORS

FACTOR	SCALE (6 -21)			(Circle and Add)	
a. Classification					
Company Private	(1)				
Classified		(2)			
Highly Classified			(3)		
b. Tempest/EMI					
Non-Tempest/EMI	(1)				
Tempest Only		(2)			
Tempest/EMI			(3)		
c. Software Size					
Under 5000 LOC	(1)				
5000 - 15,000 LOC		(2)			
15 - 50,000 LOC			(3)		
50 - 100,000 LOC				(4)	
Over 100,000 LOC					(5)
d. Logistics (development)					
One-site	(1)				
Two - three		(2)			
Three or more			(3)		
e. Documentation (requirements)					
20 or fewer	(1)				
21 - 40 documents		(2)			
41 - 70 documents			(3)		
71 - more				(4)	
f. Personnel (availability)					
Current	(1)				
6 months		(2)			
Up to 24 mo.			(3)		

Development and Maintenance. Large-scale software development projects may contain millions of lines of source code and hardware changes that occur regularly. Projects this large add to the complexity factor.

Multisite Development. Large-scale software development projects are often developed in segments at different sites and then integrated into the system. Multisite development adds to the management control, logistics, and complexity of the project.

Growth in Product Deliverables. Most projects now require and maintain more than 70 deliverable documents, each numbering hundreds of pages. Tailoring documentation to essential delivery requirements can not only accelerate delivery but reduce cost.

Development Personnel. Some classified projects require extended background investigations of their personnel. Clearance often takes up to 2 years investigation for each applicant.

Table 2 shows project factors that tend to increase complexity and, therefore, cost. Highly complex projects should receive due consideration in fee evaluations. To use Table 2 to determine degree of project complexity, higher tally = higher degree of complexity; lower tally = lower degree of complexity.

From the point tally, determine the degree of complexity and factor this into the fee request. Highly complex projects should be given just consideration in this determination.

Productivity Improvement

As complexity adds to cost, the use of CASE tools, templates, and optimum selection of document types, tailoring, and other techniques can enhance productivity for the system/software project. Customers should consider only companies that not only have the personnel, but have the tools necessary to be productive and competitive. Request for Proposals (RFPs) should include produc-

tivity factors such as advanced tools, techniques and software for due consideration.

CASE Tools for Productivity Enhancement

The use of CASE tools would allow system/software/hardware engineers not only to generate the text and graphics but to produce camera-ready copy. This advantage gives the cognizant engineer the opportunity to tailor documentation to meet project requirements, taking advantage of the Department of Defense (DOD) standards to tailor the number/types of documents to meet specific project requirements. For mission-critical computer software development, DOD Directive 5000.29 (reference a) directs the development agency to select the data items as appropriate to the system acquisition.

Tailoring Unnecessary Documentation Requirements

The Development Agency will evaluate and select applicable military standards and associated data items for computer resource development. Since all of the data items associated with each standard may not apply, the Development Agency will select and identify for delivery the appropriate data items for the system acquisition. The Development Agency will analyze the requirements for each selected standard and data item for applicability to the system acquisition, and tailor out unnecessary requirements. In making these assessments, the Development Agency will consider the need for each selected data item and each standard-imposed requirement in terms of the operational and support concepts for the system. The provisions of DOD Directive 4120.21 (reference q) will govern tailoring.

To support the documentation process, a high degree of editing and re-editing is usually required.

Style Sheets, Templates, and Other Techniques

By using style sheets and templates, documents can be tailored for each system segment requirement. The CASE tools can be used as a conduit for document development and facilitate the handling of each document. A weekly data collection scheme would permit each engineer and programmer to pass along design elements in computer-aided Unit Development Folders (UDFs). Systematic and routine collection of data for documentation purposes can be made part of the engineering cost-account responsibility. Only the user should acknowledge that the document, or portions of it, has been accepted with a rating for quality achievement provided in forthcoming review comment. The contractor should delineate the date of submission with all transmittals (for timely schedule achievement discussed later in this story) and apply internal credit as appropriate by the credit manager.

The DOD has provided standards and data-item descriptions (DIDs), identifying contract deliverable documents intended as part of the development life cycle. By using templates and tailoring, documents can be prepared quickly and easily.

To support the documentation process, a high degree of editing and re-editing is usually required. While the documentation may not change a great deal technically, the descriptive detail generated in this process will usually vary. System flow charts, detailed process flows, and screen and report layouts are time-consuming. Electronic publishing is necessary for staying competitive.[4] Aids include:

—Computerized control of page layout

—Repositioning and resizing of figures

—Automatic numbering of section headings

—Automatic header and footer notations

—Revision/version control

—Automatic cross-referencing and indexing

—Variable type fonts and mathematical symbols

—Merge of text and graphics

—Electronic transfer of data files through network-linked remote computers, to enhance productivity.[5]

Criteria for Acceptability

In order to assess productivity, criteria for acceptability must be determined as well as evaluation guidelines. Productivity measurement is determined by calculating time and/or cost saving as achieved from:

—System performance under criteria established by the purchase description (acceptance test)

—Quality of end-product deliverables established by the contract requirements (compliance).

Within the criteria, allowance should be provided that rates the delivered system and the end-product deliverables from a) superior, b) excellent, c) good, d) acceptable, and e) unacceptable. The top three categories should be held as fee-valued and quality award rating.

Other criteria for acceptance should be rated according to document attribute. For example, document size should be considered with attribute ranking for the number of pages of text and graphics, complexity of the data

item description, publication and format requirements, and qualifications personnel required in the document process. The type of document should be rated for maintainability and longevity requirement.

Personnel experience should be considered in the area of technical qualifications, continuity with the project documentation, and applicable experience with the project and the system/software.

Project management concerns like tools and guidelines, customer communication, system software requirements volatility, schedule, security factors, travel requirements, number of development sites, tools availability, and management support must be factored into the equation.

Using these factors and industry averages as established in B. W. Boehm's book *Software Engineering Economics*, performance may be assessed after system installation and delivery of all documentation products.

Data Collection and Productivity Substantiation

The program office should collect and maintain program productivity data and tool usage; areas having achieved most productivity should be identified.

The collected data on tools and areas of usage should be analyzed to determine productivity improvements and reallocated resources in accordance with priority.

To determine fee based on productivity improvements and delivered items, the following approach should be undertaken: evaluate performance against schedule (before and after productivity tools were introduced); and document feedback from critical comments and user-questionnaire; evaluate performance based on standards developed out of the COCOMO Model (taken from B.W. Boehm's *Software Engineering Economics*). The substantiation data provided should indicate the degree of complexity involved in the effort. We quote from B.W. Boehm's book, p. 571.

The amount of documentation produced for a software product has been found to be roughly proportional to the product size in delivered source instructions (DSI). Sixty percent of the effort is documentation and forty percent is code.

Example of Fee-Based Substantiation for Document Deliveries

Using Boehm's COCOMO Model (the latest and presumed to be most authoritative) as a guide to show that complex, real-time system is in the "very reliable" category is in the highest percentile of documentation effort, we may then add to this the complexity factor for dealing with highly classified documentation and the added constraints imposed; additionally, the reviews conducted by the government and coordination required for classified shipment, all affecting the total cost. Small projects may be estimated at two-man-hours per page. Large projects may be estimated at four-man-hours per page. Thus, a rough estimate of typical documentation effort (excluding complexity and productivity improvement factors) would show it to be about 50 pages per thousand development source instructions (50 PP/KDSI) of documentation multiplied by three-man-hours per page of documentation effort, results in the following equation:

(3 MH/PP) (50 PP/KDSI) = 150 MH/KDSI

or about 1 man-month per 1000 DSI for the end-deliverable product. The rates shown are industry averages indicated in the COCOMO data base. Each project must add to it the added complexities of the project and factor the productivity improvements that are expected from such aids as CASE tools, and techniques such as document tailoring. Another vital ingredient is the motivation of the project personnel. All personnel are expected to be highly motivated and qualified. Commercial enterprises have shown that inducements like awards, prizes and other motivating incentives have been successful in getting optimum productivity from employees. The next part of this paper describes an incentive plan for challenging employees to improve their productivity rate.

Incentives for Timely Accomplishment

With documentation being such a costly concern for projects with large software systems, it is important that every effort be made to ensure documents are accurate and delivered on schedule. Using a point/credit system for timely accomplishment can be challenging and rewarding to personnel, not to mention making program management happy when deliveries are made ahead of schedule.

The following describes a point system that could be used to create incentive for employees, ensure against overlooking a task during development, and allowing earlier reaction to problems that may be encountered. Program documentation problems can usually be traced to omissions or lateness brought about during earlier phases of the program.

A credit accounting system can ensure all required input is submitted at the scheduled time, and is in accordance with established standards. The system, however, is only as effective as those employing it. What is assured is that responsibilities are identified, schedules are noted, and a credit and point system in place to show achievements, and schedule gaps (to highlight areas requiring attention). Many companies employ weekly/monthly progress reporting systems. By employing a credit/point system in methodology, managers can identify and qualitatively measure achievements during weekly reviews. This creates more incentive for developers to complete documentation requirements earlier in the cycle, thus allowing earlier supervisory review, correction and delivery.

How the Credit System Would Work

Credit points should be applied if approved by the credit manager, who would receive credit only when the customer has accepted the document. The credit manager should be able to negotiate tailoring documentation items and consolidate documentation work wherever these data items are unnecessary. Credit would be given to the credit manager for any dollar savings resulting from tailoring. Points credited would be tallied and used by

FIGURE 2. PRODUCTIVITY CREDIT SUMMARY FORM

DOCUMENT	PROGRAM OFFICE				ENGINEERING					IMPLEMENTATION								CREDIT SUMMARY · POINT TOTALS											
	CDRL	PM	FI	EM	SE	HW	SW	SI	ST	PE	SC	QA	CM	TP	TR	FA	PR	SE	HW	SW	ST	QA	DC	TL	EM	TS	PM	CU	TOT
MHR EXP RPT (Monthly)	A001	△	◗																										
FUND STATUS (Monthly)	A002	△	◗																										
PROJ STATUS (Monthly)	A003	△		◖																									
PROG REPORT (Monthly)	A004	△		◖																									
CONF REPORT (As Req'd)	A005	△		◐																									
PLAN CHART (1)	A006	△		◐																									
MGMT PLAN (1)	A007	△		◐																									

Phase

(1) Requirements
(2) Preliminary Design
(3) Detailed Design
(4) Test
(5) Evaluation
(6) Training
(7) Operational
(8) Maintenance

[△] Credit Mgr
[○] Respon Engr

Point System

One point for ea com- pleted review
Ten points for customer approval
Five points for final delivery Approved/Distributed Document
N/A = 1 point

Abbreviations

CU = Customer
CM = Config Mgmt
CR = Credit Mgr
DC = Doc Coord
DE = Doc Engr
EM = Engr Mgr
FA = Fabrication
FI = Finance
HW = Hardware Engr
PM = Program Manager
PR = Provisioning
QA = Quality Assurance
SC = Scheduling
SI = Software Integration
SW = Software Engineering
SE = System Engr
ST = System Test
TL = Task Leader
TR = Training
TS = Technical Support Mgr
TP = Technical Publications
IM = Implementation Mgr

section supervisors/managers as consideration for merit raise, and/or productivity bonus award. Quality rating would be applied only by the customer and reviewed during the negotiation for fee.

The form shown in Figure 2 can be used to keep credit status of documents in process.

Summary

Credit accounts are established for managers and participating program personnel for engineering input requirements. A credit system is used throughout the program to perform a check-and-balance mechanism on the entire program. Standards for qualitative reviews are provided to the credit managers. Weekly reporting is required. A credit management approach will help ensure against oversight and keep product deliveries highly visible.

Technology available today can improve productivity, if used correctly. A graphics work station coupled with a powerful word processor can provide great enhancements to most current documentation approaches. A methodology encompassing modern tools, standardization techniques, and consistent application by developers can provide the necessary drivers. A credit accounting system can help ensure all required input is submitted at a scheduled time and in accordance with established standards. Whether a system is a new computer or a military weapon system, the documentation must be in the hands of the user with the delivery of the system.

Conclusion

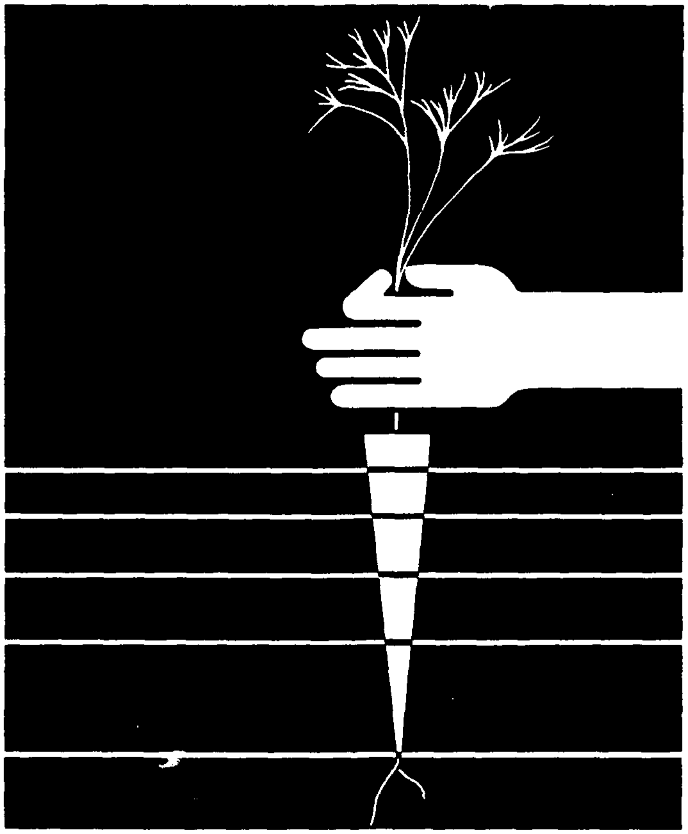
We began with a quote from Frank Dr.uding's article, "Looking for the Right Pond," and we conclude with another quote from the same article:

> Imagine how different documentation would be....The only documentation needed would be an architectural equivalent to a hardware logic flow diagram—a series of separable top-down, structured CPCI descriptions, and a simple standardized interface description document....How much could we save toward improved productivity? Probably a substantial amount.

(See DOLKAS/GOVIER, page 59)

CONTRACTING WITH AN AWARD FEE—IT WORKS!
(BUT NOBODY SAID IT WOULD BE EASY)

Captain Gregory A. Garrett, USAF



Case in point: The B-1B bomber Computer Integrated Test System (CITS), which monitors most of the aircraft's system functions such as wing sweep positions, line pressure, ordnance status, etc., was originally specified by the government to have a limit of two percent or less of false alarms. In reality, B-1B aircrews were typically seeing more than twice that amount of false alarms. The B-1B System Program Office (SPO) engineers at Aeronautical Systems Division working with contractor's B-1B engineers were able to make several quick fixes to reduce the number of false alarms down to the required limits in a relatively short time. However, it became readily apparent that the government's originally required limit of two percent or less was inadequate and simply did not satisfy the needs of the user—USAF Strategic Air Command.

The government engineers then came to SPO contract managers for guidance and assistance in developing an incentive program by which the contractor would become highly motivated to lower the percentages of false alarms even further. A reduction in the CITS false alarm rate would reduce maintenance costs incurred to investigate if the alarms were the result of real or false problems and it would, in turn, increase aircraft availability. After conducting meetings between the government and contractor engineering, and contract management personnel, it was agreed that further reduction in the number of CITS false alarms would be a highly complex software engineering effort and a very difficult management task, because those false alarms remaining were the hard-to-fix items.

You see, even though the amount of reduction in false alarms could be objectively measured, the means by which to accomplish this reduction via changes in software consisted of cost, schedule, and quality requirements that could not be feasibly or effectively predetermined objectively. Thus, the parties agreed to incorporate the CITS improvement effort via a Fixed Price Incentive Firm with an Award Fee (FPIF/AF) type of contract modification to the B-1B development contract.

The inclusion of the award fee provided the contractor an excellent incentive and resulted in a true Win/Win situation for both the government and the contractor. The government won by having the false-alarm rate lowered to less than .03 percent, due to the contractor's high management emphasis on quality, timeliness, and cost-effectiveness.

This CITS false-alarm rate of .03 percent represents a significant savings in government maintenance manpower and hours (an estimated 3,700 manhours per year, per base) in checking mostly false alarms.

The contractor also won in this effort by receiving a return on investment which was significantly greater than their normal amount for the cost they expended. However, I contend that in this instance and in other cases perhaps just as vital if not more important to the contractor, the award fee application is successful because it prompts visibility, support, and favorable recognition of the effort by upper-corporate management. The participation and positive recognition by upper-management can serve to motivate the contractor team to achieve exceptional performance. Further, the favorable recognition from the government for a job well done can result in good media attention and coverage for the company, which in today's government contracting environment could be considered a rare and endangered form of media, thus a valuable commodity. Truly, when both parties involved in a contract win, then you know the system is working.

So, now that you know that contracting with an Award Fee *can* work, you might be asking youself some of the following questions:

— What exactly is an award fee?

— When should an award fee be used?

— How is the amount of available award fee originally established?

— How is the contractor's performance evaluated?

— What are the disadvantages to award fees?

The answers to these questions range from simple to complex, but, in the following paragraphs I shall attempt to answer them for you.

What exactly is an award fee? It is a subjectively determined amount of money paid to a contractor by the government for an effort which the contractor has performed on an award fee basis. Contracts with an award fee, such as a Cost Plus Award Fee (CPAF) contract, usually include, according to Federal Acquisition Regulation (FAR) 16.404.2, a fee consisting of the following: (a) A base amount of funds established at contract inception, typically ranging from zero to three percent of cost, and (b) an award amount the contractor might earn in whole or part during performance of the effort. This amount must be sufficient to provide the contractor motivation for excellence in critical areas including timeliness, quality, technical performance, and management effectiveness. Key elements to an award fee are that it contains a base fee portion and an award fee portion and that the fee is subjectively determined by the government, based upon the government's evaluation of the contractor's performance.

> The participation and positive recognition by upper-management can serve to motivate the contractor team to achieve exceptional performance.

In addition, neither the government nor contractor can unilaterally establish an award fee contract between the parties; it must be mutually agreed to and bilaterally executed. After the contract is awarded, the award fee is usually paid in intervals based upon evaluations and a fee determination for specific periods of time and for specific level/amounts of performance. Another point to remember is that an award fee can be used on both new contracts and on contract modifications of various types including: Cost Plus Award Fee (CPAF), Fixed Price Incentive Firm with an Award Fee (FPIF/AF), Cost Plus Incentive Fee with an Award Fee (CPIF/AF), and other types of contracts.

When should an award fee be used? According to FAR 16.404-2, award fees should generally be included in contracts when the following three items are applicable. *First*, the work to be performed is such that it is neither feasible nor effective to devise predetermined objective incentive targets for cost, technical performance, or schedule requirements.

Second, the likelihood of meeting acquisition objectives will be enhanced by using a contract that effectively motivates the contractor toward exceptional performance and provides the government with the flexibility to evaluate both actual performance and the conditions under which it was achieved.

Third, any additional administrative effort and cost required to monitor and evaluate performance are justified by expected benefits. If these three items are applicable to a contract and/or contract modification you are involved with, perhaps you should consider using an award fee. Some government program managers of major programs place especially high value on the use of award fees because of the management capabilities it provides them as a tool to motivate contractors to superior performance. One caution: There are a few FAR imposed limitations on award fees including the maximum fee payable, depending upon type of contract (FAR 15.903), expected benefits versus the additional administrative cost, and other limitations stated in FAR 16.301-3.

How is the amount of available award fee originally established? The answer to this question is: It depends. Various government contracting agencies will employ different methods to originally establish or determine the appropriate total amount of available award fee, which will serve to effectively motivate a contractor to achieve superior performance. Clearly,

deciding upon the total amount of available award fee is an important part of the award fee planning process. The government does not want to provide a contractor too large an incentive "carrot," or too small of one. Some methods government contracting agencies have used to determine appropriate amount of available award fee range from developing elaborate means to calculate technical complexity and management risk, to simple calculations of possible contractor rates; for example, Return on Investment, Return on Assets, etc., compared to similar efforts. However, another caution, the Department of Defense FAR Supplement (DFAR) 16.404-2 clearly states that the weighted guidelines method shall not be applied to CPAF contracts with respect to either the based (fixed) fee or the award fee. Since there is no one government mandated method for determining the appropriate amount of available award fee, the task of deciding upon an appropriate available award fee amount is up to the respective contracting activity. Yet, as stated, depending upon the situation, the monetary reward is usually not the sole motivator for a contractor in an award fee process.

How is the contractor's peformance evaluated? This is when the fun begins. The contractor's peformance on a contract containing an award fee provision is evaluated per an Award Fee Plan, written for the applicab'. effort. The Award Fee Plan is a detailed document prepared by the government which includes: the reasons for using an award fee, a description of the evaluation organization, its structure, responsibilities, and procedures, an explanation of the distribution of award fee funds to performance periods, and a precise breakdown of the evaluation categories, criteria, and possible performance ratings (see DFAR 16.404-2 for examples of the evaluation criteria and contractor evaluation report). The entire award fee evaluation process of an effort performed on an award fee basis is essentially governed by the Award Fee Plan, and key elements of the plan are the evaluation criteria.

Simply stated, if that is possible, the typical award fee evaluation process, which begins after the award fee effort has been placed on contract, consists of the following six primary steps for each award fee period.

First, the contractor completes the required effort for a specified award fee period and then the contractor prepares a report to describe their performance using a self-evaluation process.

Second, the government award fee performance monitors prepare reports to detail their assessment of the contractor's actual performance versus the evaluation criteria established for the same period and effort.

Third, these reports are submitted and usually presented to an Award Review Board (ARB), which is responsible for conducting an in-depth review of relevant areas of actual contractor performance versus the established evaluation criteria.

Fourth, the ARB reviews the respective report and prepares an Award Fee Evaluation Report (AFER) that is submitted to the Fee Determining Official (FDO), usually the program manager.

Fifth, the FDO reviews the AFER, discusses it with the ARB and then usually receives an award fee self-evaluation presentation from the respective contractor.

Sixth, the FDO makes the award fee determination and then the contractor is notified and later paid via a contract funding modification. Two important points to remember about the award fee process are; the FDO award fee determination is not subject to the Disputes Clause, and the process discussed above is the typical evaluation process and, as such, is subject to change.

What are the disadvantages to award fees? As mentioned, two principal disadvantages of contracting with an award fee are the cost required to monitor performance and the associated administrative effort and cost to evaluate the contractor's performance for the specified award fee periods, at the completion of each period. Another common disadvantage of contracting with an award fee is that few contracting and related acquisition personnel in government and industry are knowledgeable and experienced in detailed policy, procedures, and applications of award fees. Thus, most often, using award fees on government contracts requires extensive education and training of contracting and related acquisition personnel to ensure a successful award fee application. Certainly, disadvantages discussed above are not the only possible problems and the significance they may, or may not, play depend upon unique aspects of each situation. If you realistically assess potential advantages and disadvantages, I believe you will conclude that contracting with an award fee often makes sense.

Now that you know what an award fee is, when they should be used, how the fee amount is established, how contractor performance is evaluated, and a few pros and cons of using award fees, you have an overview of some key elements in this unique conatractual process. Clearly, using award fees on government contracts to motivate and reward contractors to achieve government acquisition requirements and goals is a topic subject to debate and is far more involved than is discussed here. Yet, if you are planning an acquisition that has a problem calling for a contractor's performance over and above that which can be objectively measured and incentivised, under other than "usual" forms of government contracting, your solution may be contracting with an award fee.

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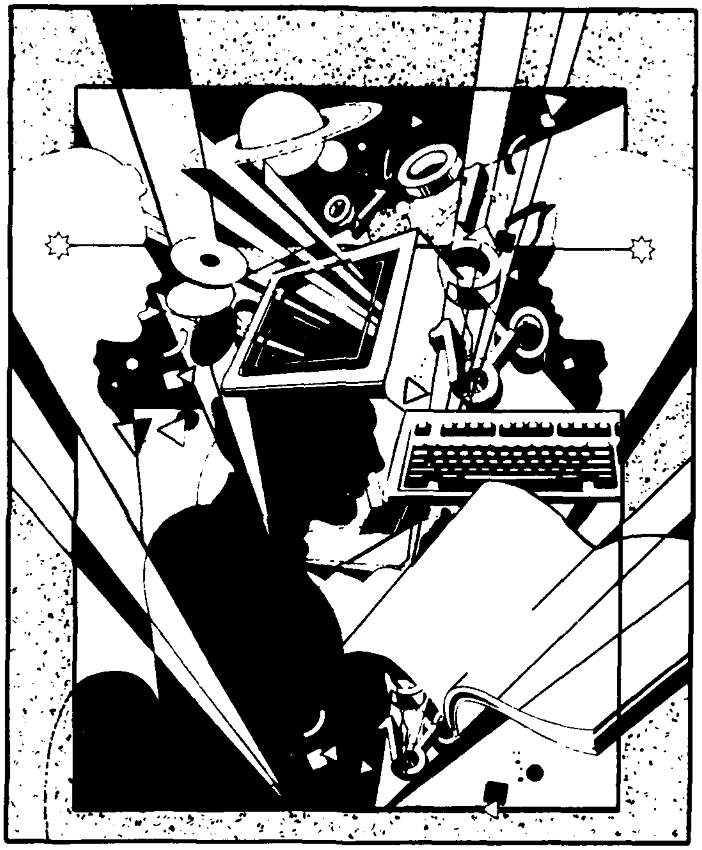
DSMC SIMULATIONS
(GAMES THAT TEACH ENGINEERS AND SCIENTISTS HOW TO MANAGE)

Dr. Owen C. Gadeken



In an earlier *Program Manager* article, "Why Engineers and Scientists Often Fail as Managers (and What to Do About It)," I summarized existing studies regarding engineers and scientists who transition into management careers.[1] Little research had been done on this topic, and most was without regard for job effectiveness either before or after the transition. However, several studies [2,3,4,5] cited technical managers deficiencies in interpersonal skills when compared to managers with non-technical backgrounds. One of the references[6] further stated that successful technical managers were rated higher on interpersonal skills than the less successful technical managers in their study. Other sources [7,8] revealed that engineers saw themselves and their undergraduate curricula as markedly deficient in developing their human relations and communication skills.

The implications of these findings is that engineers and scientists need more interpersonal skills development to enhance their selection opportunities, career development and successful performance as technical managers. These implications are particularly relevant for the Defense Systems Management College since engineers and scientists make up approximately two-thirds of each Program Management Course and up to three-fourths of DSMC executive courses.

Organizational Simulations

The usual approach for academia or organizations that recognize the need to develop stronger communication and interpersonal skills is to add human relations courses or seminars.[9,10] However, at least one author[11] concludes that this may be the wrong approach and that experiential exercises such as simulations and role playing would be more effective training methods.

Rather than re-investigate the more traditional methods of managerial leadership training, the Defense Systems Management College chose to conduct a more detailed demonstration of a newer training method. The organizational management simulation was selected based on its growing popularity and on its design which includes feedback on participants' interpersonal skills.

Organizational simulation training is related to role-playing, but differs in two significant respects. First and most important, simulations differ from role-plays in that participants are instructed to be themselves in the situation rather that act out a prescribed role. Thus, simulations are better suited to elicit real managerial behavior of participants for diagnosis of both their strengths and weaknesses. Second, role-plays are usually individual or small-group exercises, while organizational simulations are larger and more complex in scope; e.g., several levels of management can be included. Thus, organizational simulations can better mirror the many hierarchical and lateral relationships present in most organizations, and especially in Department of Defense systems acquisition organizations.

After selection of the organizational simulation as the training method, the next step was to select the specific

simulations to be used in the research study. Three large-scale (at least 20 participants) simulations were found to be commercially available. Each simulation was screened in detail including a review of the materials and interviews with the developers. After the screening, two of the simulations were selected for trial runs. These trial workshops were run by the simulation developers and used DSMC faculty as participants. After trial runs, the Looking Glass was selected as the simulation to be used for the research project based on the positive feedback from the faculty participants, the research data base accompanying the simulation, and the established training program for licensing the simulation to users such as DSMC.

Looking Glass Simulation

Looking Glass is a six-hour simulation of a glass manufacturing company with more than $200 million in sales and 4,000 employees. The simulation was developed by the Center for Creative Leadership (CCL) from 1976 through 1979 in a $300,000 project supported by the Office of Naval Research.[12] The CCL is a non-profit research and education organization founded by the Smith Richardson Foundation. (H. Smith Richardson invented and marketed Vicks VapoRub.) Looking Glass was initially developed as a laboratory research tool to study organizational behavior and leadership as an alternative to field research. After repeated demands from research participants for feedback on their individual performance, CCL evolved a stand-alone training program around the simulation. This program was based on the concept of experiential learning; i.e., involving participating in an experience and then reflecting on their performance and the results achieved.[13]

In each simulation, the 20 participants occupy the top-management positions in the Looking Glass company ranging from president to plant manager. There are three operating divisions, each of which faces a different internal and external environment.

Participants are introduced to the simulation on the afternoon before it is run in a session designed to familiarize them with the company, their positions, and each other. During the session, participants and training staff are introduced, a slide program about the company is shown, participants are assigned or select their positions, and each participant is given his or her in-basket material to review before the next day.

After short administrative remarks the next morning, the Looking Glass company opens for business. The intercom telephone system is turned on and participants return to their desks to start the day. Their in-baskets are filled with major strategic and operational constraints, division history and product information, financial data, and other relevant facts and figures. In all, more than 100 problems are distributed throughout the in-baskets. They cover such diverse areas as finance, personnel, legal action, production, sales, research and development, publications, and safety. Some example problems include:

—An opportunity to acquire a new plant

—Deciding what to do with a non-profitable plant

—Violation of pollution standards

—Discrimination in hiring

—Raw material supply shortages

—Production capacity limits

—A lawsuit with a major customer

—Competition with foreign manufacturers

—Filling a vacant plant-manager position.

A unique characteristic of the Looking Glass simulation is the freedom allowed participants. They can take whatever action they please consistent with their normal management style. They can call meetings, make phone calls, write memos, have informal discussions, make decisions, or wander around. By memo, phone or in person, participants can contact anyone inside or outside the company. Trainers play the outside roles and respond by telephone or memo (not in person) using a detailed book of background information. However, the primary function of the training staff is to be unobtrusive observers of the actions and behaviors of the participants. Further insight into the Looking Glass simulation is available in a recent (May-June 1988) *Program Manager* article by Michael G. Krause.[14]

The 6-hour simulation concludes with a brief address by the president on the state of the company. This is followed by a set of detailed questionnaires on which participants document the information they knew, the problems they addressed, the decisions that were made, their interaction with each other, and the relative effectiveness of their peers and their division. This information is combined with the trainers' observations of the activities that took place during the simulation to conduct a 10-hour series of debriefing exercises designed to help the participants identify their strengths and weaknesses as managers and set goals for improvement. The debriefing process is based primarily on participants' reflections on their behavior and the outcomes resulting from it. At the end of this debriefing session, participants are given goal sheets and asked to prepare managerial self-development goals based on their participation in the Looking Glass workshop.

The workshop normally concludes with assembly of all participants and DSMC trainers for a short session where participants post their major learnings on poster paper positioned around the room. After the workshop, participants are encouraged to hand in their goal sheets. For two of the workshops, an additional half-day goal setting session was held on the morning following the workshop. This session reviewed the process and importance of goal setting and allowed participants to discuss their goals and implementation plans with each other in small groups.

Evaluation Approach

The method chosen to evaluate the effectiveness of the simulation was the Participant Action Planning Approach (PAPA) from the U.S. Government Office of Personnel Management (OPM).[15] This involves each training participant in preparing a personal action plan immediately after completing the training program. Participants

were given goal sheets at the end of the Looking Glass workshop and asked to identify management development goals based on their participation in the workshop. Each was asked to develop at least one written goal and return the carbon copy provided with each goal sheet to the Defense Systems Management College for research study. Participants were not required to develop goals if they felt they did not want to make planned changes in their management behavior at the time. Three months after the workshop, participants with written goals were sent a follow-up questionnaire for each goal asking for specific information on actions and results obtained when they tried to implement their goals. Participants were asked if they had made any other changes in their management behavior which they would attribute, directly or indirectly, to their participation in Looking Glass. An abbreviated follow-up questionnaire was sent to Looking Glass participants who had not developed written goals. It asked only about changes in their management behavior they would attribute to having participated in Looking Glass.

> Unique characteristic of the Looking Glass simulation is the freedom allowed participants. They can take whatever action they please consistent with their normal style.

Research Participants

Two DSMC courses were selected for demonstration of the Looking Glass simulation: the 20-week Program Management Course (PMC) and the 4-week Program Managers' Workshop (PMW). The PMC, the College's primary offering, is designed for mid-level managers. The PMW was a special refresher course for designated major system program managers and their deputies. (DSMC discontinued PMW at the end of FY 1987.)

The DSMC student participants typically came with one of two separate types of work experience: They were either technical specialists with considerable experience in one specific field or discipline (such as contracting or design engineering), or experienced military combat officers for whom systems acquisition was a career-broadening assignment. The participants' work experience in development of weapon systems ranged from 0 to 30 years with the average 6.1 years. Approximately 60 percent of the participants were military. The other 40 percent were civilian. Military participants ranged from captain (0-3) through colonel (0-6) with the average rank being a senior major (0-4). Civilians ranged from General Schedule(GS) 9 through 15 with the average grade being GS-13. The PMC participants ranged in age from 27 to 57 with the average at 40 years, while PMW participants ranged from 37 to 65 with an average at 45 years. All but 7 of the participants were male.

Control Group

A group of PMC students not participating in the workshops served as a control. They were given goal sheets and the same request to develop at least one written goal. Their goals were to be based on their learnings from the PMC which included several seminars on leadership, communications, and interpersonal relations. Approximately two-thirds of both the participant and control groups had science or engineering undergraduate degrees. The overall design is summarized in Table 1.

Research Hypotheses

The research hypothesis was that organizational simulation training increases the number of managerial leadership goals both set and achieved

TABLE 1: RESEARCH DESIGN

Group	DSMC Course	Students	Looking Glass (2½ days)	Goal Setting (½ day)	Goal Sheets	Follow-Up (after 3 mo.)
Test	PMC	60	Yes	No	Yes	Yes
Test	PMC	40	Yes	Yes	Yes	Yes
Control	PMC	100	No	No	Yes	Yes

to a greater extent than classroom or seminar programs (i.e., DSMC management courses). This hypothesis was tested using the Looking Glass (LG) organizational simulation in five separate 3-day workshops with a total of 100 DSMC students. Results were measured as the number of managerial leadership job behavior goals set and achieved after the workshops using the Participant Action Planning Approach (PAPA).

Four separate measures were used:

1. The number of goals submitted
2. The number of submitted goals that dealt with improving managerial leadership skills
3. The number of managerial leadership goals from 2 above that were achieved in the follow-up survey
4. The number of new managerial leadership actions reported by individuals on the follow-up survey that were derived from participating in LG but had not been stated as written goals.

Since not all students were scientists or engineers and participants came from two different courses (PMC and PMW), comparisons between LG participant subgroups were made as shown below. Engineering, science, and other education refer to the bachelors degrees of the students.

LG Participant Versus Control Group Comparisons

DSMC Students (LG) vs. DSMC Students (Control)
Engineering/Science (LG) vs. Engineering/Science (Control)
Other Education (LG) vs. Other Education (Control).

LG Participant Subgroup Comparisons

Engineering/Science (LG) vs. Other Education (LG)
Science (LG) vs. Engineering (LG)
PMW Students (LG) vs. PMC Students (LG).

Statistical Procedures

The statistical approach used in the data analysis was hypothesis testing for equality of means of the different samples compared. Since the intent of the research was to demonstrate that by going through Looking Glass, participant groups would exceed their control groups on each of the measures studied, each alternate hypothesis was stated as a one-tailed test. Since some of the sample sizes were less than 30, the t-distribution and t-test statistic were used for all sample comparisons as a conservative measure. Population variances were unknown, so equality of sample variances was confirmed before each statistical test for means. Since the samples being compared were not all of equal size, the Bartlett test procedure was employed. The .01-level of significance of the test statistic was used since the Bartlett test is robust with respect to moderate violations of the homogeneity assumption.[16]

Results

Table 2 is a comparison of LG participants versus their control groups on the first three measures described earlier. The fourth measure, new managerial actions, was not used here since only participant groups had attended LG and could comment on new behaviors resulting from it. Based on the one-tailed tests for correlated means, LG participant groups exceeded their control groups (at the alpha level) in all but one instance.

Comparisons among LG participant subgroups were made using the standard t-test procedure. No differences were found to be significant (even at the 0.05 level).

Discussion

The PAPA goal setting exercise showed positive results for workshop participants especially in goals submitted and leadership goals. The LG workshop was particularly effective in getting engineers and scientists to submit goals compared to the other education group (from Table 2): Engineering/Science Goals Submitted, LG, 15.4—CONTROL, 3.6; Other Education Goals Submitted, LG, 11.6—CONTROL, 8.6.

However, the engineers and scientists goals were not necessarily more leadership oriented than the other education group (from Table 2): Engineering/Science Leadership Goals, LG, 7.6—CONTROL, 0.4; Other Education Leadership Goals, LG, 6.4—CONTROL, 1.0.

A logical extension of the increase in managerial leadership goals set and achieved by Looking Glass participants, particularly engineers and scientists, would be expected improvement in on-the-job performance in specific managerial leadership skills. Clearly, this hypothesis was not part of the research design that focused exclusively on goal setting. However, some connections to existing managerial leadership theory were made and are discussed briefly in the following paragraphs.

Based on the work of Harvard psychologist David McClelland, an applied model of managerial leadership was developed by Boyatzis[17] using behavioral competency measures taken from critical event interviews with more than 2,000 managers in 41 different industry and public-sector jobs. Cluster and regression analysis were used to link specific skills with effective performance on different jobs. Competency clusters were identified for the different jobs. While each cluster was unique, several competencies were found to be common across all of the jobs studied. A simplified list of these common competencies was used as the criteria for determining which LG participant and control group goals were categorized as managerial leadership related. Table 3 breaks out the LG participant managerial leadership goals by competency area. Note the concentration on the interpersonal relations area. Typical goals is this area involve improving networking relationships, informal communications, listening skills and image. Participants reported 54 new or improved managerial leadership behaviors they derived from LG and for which they had not set goals.

TABLE 2.
LOOKING GLASS PARTICIPANT VS. CONTROL GROUP COMPARISONS ONE SIDED ALTERNATE HYPOTHESIS H_a: $u_1 > u_2$)

(Entries normalized for 20 students; i.e., one Looking Glass workshop)

A. Total Group			
Item	(N=96) LG	(n=96) Control	Significance
1. Goals Submitted	13.8	5.6	**
2. Leadership Goals	7.0	0.6	**
3. Goals Accomplished	5.4	0.4	**
B. Engineering/Science			
Item	(n=56) LG	(n=56) Control	Significance
1. Goals Submitted	15.4	3.6	**
2. Leadership Goals	7.6	0.4	**
3. Goals Accomplished	5.4	0	**
C. Other Education			
Item	(N=40) LG	(n=40) Control	Significance
1. Goals Submitted	11.6	8.6	n/a
2. Leadership Goals	6.4	1.0	**
3. Goals Accomplished	5.6	1.0	**

n--number of students
* Significant at 0.05.
** Significant at 0.01.

TABLE 3.
LOOKING GLASS PARTICIPANT GOALS BY COMPETENCY AREA

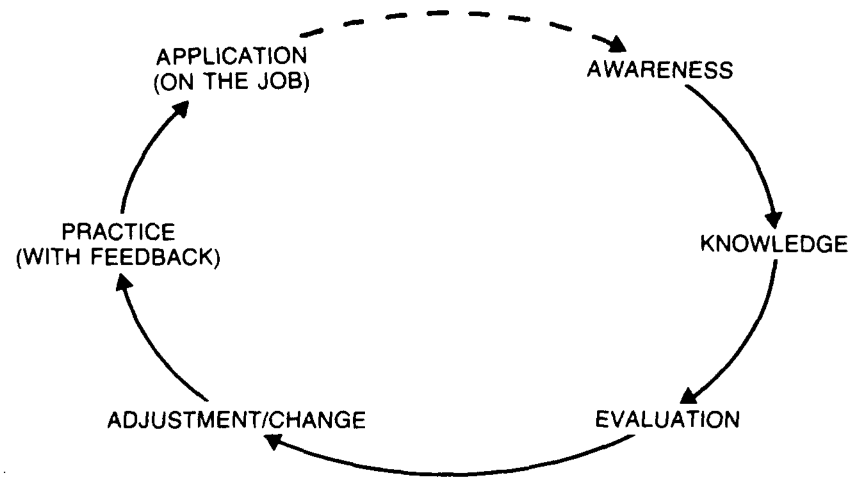
(Total for Five Looking Glass Workshops)

Competency	Managerial Leadership Goals Submitted	Managerial Leadership Goals Accomplished	New Actions
Conceptual Focus	—	—	5
Goal Orientation	2	1	2
Initiative	3	3	1
Problem Solving	2	2	2
Efficient Use of Resources	5	4	5
Interpersonal Relations	15	11	26
Influence (Power)	4	3	5
Oral Presentation Skills	1	1	—
Self-confidence	—	—	5
Objectivity	—	—	—
Persistence	1	—	—
Adaptability	1	1	3
TOTAL	34	26	54

SOURCE: DSMC

A competency acquisition process model was developed from this research and it is presented in Figure 1. The first three steps (awareness, knowledge, and evaluation) are the normal results of classroom instruction. But, as the model illustrates, these steps are insufficient to fully develop managerial competencies (skills) unless they are followed by opportunities to adjust, practice, and get feedback on performance. Boyatzis states: "Too often training programs attempt to 'teach the fundamentals' using lectures, readings, case discussions, films, and dynamic speakers to transfer knowledge to course participants. Unfortunately, it is usually not the lack of knowledge, but the inabilty to *use* knowledge that limits effective managerial behavior."[19]

FIGURE 1. COMPETENCY ACQUISITION MODEL



SOURCE: McBER AND COMPANY, BOSTON, MA.

This statement was reinforced in an interview with Dr. Boyatzis,[20] McBer's president, who said in all managerial jobs they studied in government and industry, in only one case was there a significant difference in the knowledge possessed by the top performers when compared to average performers in the same jobs.

It is clear that the voluntary nature of the goal-setting exercise limited the goals both set and accomplished (all measures were less than one per person). Still, there was a large difference between the participant and control groups. Both participant and control group members had received similar DSMC classroom instruction on fundamental principles of managerial leadership and the need to develop communication and interpersonal skills for their upcoming jobs. So, the significantly increased goal performance of the participants points to the added value of experiential exercises as motivation for goal setting and accomplishment.

This research study supports the competency acquistion process model with data from an organizational simulation (Looking Glass) which features practice and feedback to ensure transition of training results to the job environment. Referring to the competency acquisition model in Figure 1, both the LG participants and control group members progressed through the first three steps (awareness, knowledge, and evaluation) in the classroom as DSMC students. The Looking Glass simulation took the participants further along the competency development process (through practice with feedback), which based on the model would be expected to lead to more improved managerial leadership job behaviors. This is consistent with the observed results of Looking Glass participant leadership goals set and accomplished in Table 2.

DSMC Applications

Using the organizational simulation concept, the Defense Systems Management College has restructured the 20-week Program Management Course into 6 weeks of classroom instruction (Part I) followed by 14 weeks designed around an organizational simulation of the life-cycle development of a new weapon system. Part I covers fundamentals of various acquisition disciplines including acquisition policy, business and technical management. Then, Part II focuses on integration and application of these disciplines within a series of complex but realistic scenarios. Students, in effect, become the program management office and must confront and resolve each situation as they move "their" program from a paper design through hardware delivery to the operational (using) command.

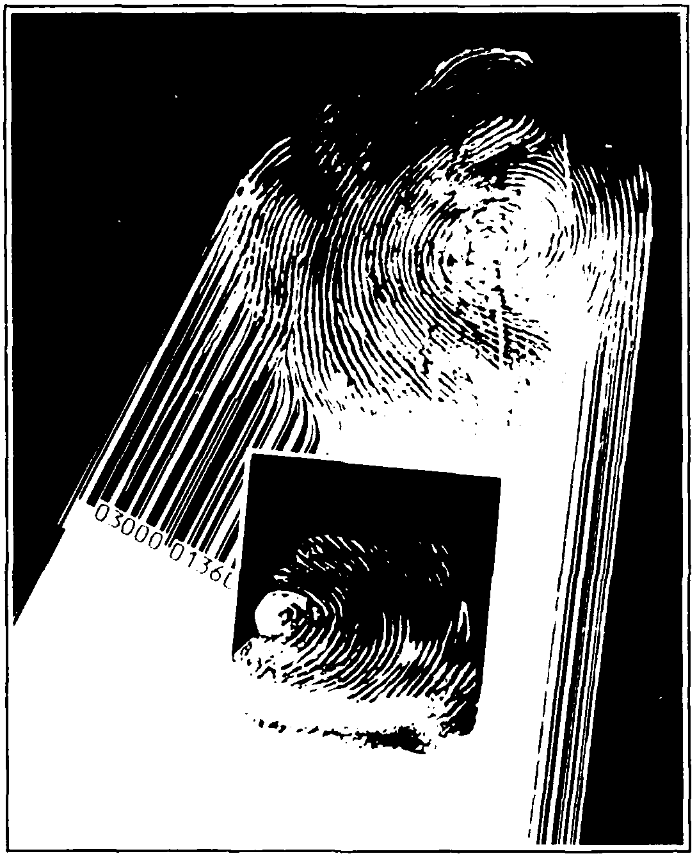
Scenarios give students the chance to test and apply classroom learning before the outcomes involve real dollars, hardware and people. Students are expected to assume different roles as the simulation progresses. Besides taking a turn as program manager, students can walk in the "shoes" of the acquisition functional managers whose competent and collaborative performance are equally necessary for the program to succeed.

The organizational simulation approach in PMC has many benefits. First of all, it confirms students' mastery of the knowledge base of defense acquisition. Second, it tests students' ability to integrate and apply this knowledge in realistic situations. Third, the simulation gives students an opportunity to experience the different functional and organizational perspectives affecting the outcome of every defense acquisition program. Fourth, it gives students a sense of what it is like to work in a program office and manage a real acquisition program. Such a feeling (or gestalt) is almost impossible to achieve in the classroom. Fifth, and most important, simulation focuses on demonstration of students' leadership and management skills. The simulation tests students' vision, judgment, communication and teambuilding: skills that have made and will

(See GADEKEN, page 39)

EFFICIENCY AND PRODUCTIVITY: HOMAGE TO THE CODE

Dr. Lewis H. Blakey



For a century, fingerprints have been used as the unique imprint of an individual. They represent that person's distinctive symbol or totem. Recently, a more complex and exact imprint has been uncovered by biologists—an individual's genetic code. The genetic code is most often portrayed as a series of dark and light bars. This is similar to, and reflects the same principles as, the bar codes that appear on each package or product bought at the supermarket today.

Those small vertical stripes readily visible on packages at the supermarket and more recently on all kinds of equipment are actually fingerprints readily identifiable by a scanner when fed into a computer. Bar codes have been with us for well over a decade, although to the layman they seldom appeared to have a purpose. With time, as more bar-code reading equipment was installed, their purpose became evident. Today, bar codes are used in various manufacturing and distribution functions. Primary benefits of using bar codes for inventory are accuracy and increased productivity. Bar-coding applications have been extended to scheduling problems, resulting in better budgetary control and substantial cost savings.

The Department of Defense has a huge, complex, and often incompatible inventory system. There is clearly a need for literally keeping track of millions of items, ranging from tanks and computers to automative parts. Simple property inventory, in itself, is a laborious task, and a simple and accurate system represented by bar codes would more than pay for itself. But the real value of bar coding is that it can also be tied to scheduling of replacement parts, related maintenance activities, and the allocation of personnel and budgetary decisions. This feature is directly linked to the ability of a Director of Engineering and Housing (DEH) at an Army installation, for example, to estimate in a better way projected purchasing needs for various parts and materials within an evermore stringent operating budget. The likelihood of inadvertent stockpiling or inadequate purchasing can virtually be eliminated. That is the hidden value of bar coding.

Bar Code Symbology

A bar code can be defined as an arrangement of dark rectangular marks alternated with light spaces (Paquette 1987). Size and distribution of the dark rectangular bars, combined with the spacing and size of the light bars, determine the type of bar code employed. The specific combination used is called the symbology. However, one should not make the mistake of assuming that codes and symbols are the same in bar coding. A code is the computer depiction of the symbol, while the symbol is the physical representation of the code; i.e., what you see or a particular combination of

characters which is fed into the computer. Most codes are bidirectional; that is, they can be read from either the left or right side.

A connecting device is always necessary to help the computer interpret the bar-code marks. Bar-code readers, wands and scanners are terms commonly applied to hardware currently available. Two different kinds of scanners, one stationary and the other portable, can be used together or separately, depending on the application. Further, there are many different technologies that can be used in conjunction with either the portable or stationary scanners including a fixed beam, moving beam, light pen, and imaging array (Wilderman 1978). The moving beam is capable of reading codes from as far away as 18 inches, whereas the light pen needs physical contact with the printed code to do its job.

Although, to most people, all bar codes look the same, hundreds of different symbologies have been developed, most with a specific application in mind. The one that is best known and most frequently visible is, of course, the Universal Product Code (UPC), which was introduced into the grocery store as early as 1974. The UPC bar-code symbology, however, was created as a numeric code, making it unusable for industries where alpha numeric character combinations are employed.

DOD Actions

The Department of Defense (DOD) clearly has a need for this technology and hoped to capitalize on the advantages of bar coding for their many purposes. However, because there was no standardization in bar coding, it looked to a special *ad hoc* committee for an alternative. Based on the committee's recommendations in 1981, the DOD officially adopted Code 39, also known as Code 3 of 9, into its Logistics Applications and most often referred to by the acronym LOGMARS (Logistics Applications of Automated Marking and Reading Symbols). Code 39 was selected because this specific symbology could best serve anticipated needs of the DOD which included marking supply items, unit packs, outer containers and certain documents. By 1982, the DOD was requiring the use of LOGMARS on all unit packs and outer containers entering its logistics system.

Based on the committee's recommendations in 1981, the DOD officially adopted Code 39, also known as Code 3 of 9, into its Logistics Applications and most often referred to by the acronym LOGMARS.

Shortly afterward, the Automotive Industry Action Group, many members of which had been on the DOD *ad hoc* committee, recommended adopting Code 39 for their organization. The Motor Equipment Manufacturers Association was quickly tasked to develop guidelines by which these codes could be used in the aftermarket (Guidelines 1986).

In 1985, a DOD-wide Documentation Test Project was developed by the joint services LOGMARS Documentation Subgroup to implement the DOD Standard Symbology (LOGMARS 1987). The LOGMARS final report had recommended that interservice coordination be effected in the areas of shipping and receiving to make sure that the DOD Standard Symbology was applied uniformly throughout the DOD.

The test project compared procedures for documentation that were current at that time; i.e., were processed by manual methods through key entry of data into manual or mechanized systems with bar-coded substitutions. The shipping and receiving documents affixed to material coming through the logistics system were tested at the wholesale and retail levels by using bar-coded replacements for two DD forms and a military shipping label. The tests proved successful, demonstrating a drastic reduction in paperwork, a big improvement in productivity, and an increase of receipt, issue shipment and intransit data reporting accuracy. In fact, there was no report of any significant negative aspects in applying LOGMARS technology in the test study of improvements in shipping and receiving of equipment.

Current Applications

Since testing of the prototype bar-code system, benefits of LOGMARS have been snowballing—always increasing productivity, reducing error rates, and improving responsiveness of automated systems with significant cost savings. A recent article in the American Society of Civil Engineers' *Civil Engineer* highlights an Air Force bar-coded Equipment Management Accounting System (EMAS) that follows the maintenance, warranty information, and location of $0.5 billion in equipment and supply assets (Bell 1988). Costing $1 million, EMAS is expected to save more than $4 million due to improved tracking of equipment loaned out, reduction of fraud and waste, and reduction in manpower. Also mentioned are a bar-coded munitions inventory system that has shown an 80 percent reduction in the time required for inventory and an automated tool control system at two Army depots using bar-coded tools and employee badges which have an estimated savings of $400,000.

All of the Services are trying to apply bar-code technology to their respective missions. While many of these applications have yet to be approved and applied DOD-wide, the Army seems to be ahead of the other Services in using bar codes. The LOGMARS applications are keeping

track of Army property in such diverse areas as transportation, distribution, service store inventory, retail receiving, wholesale shipping, and depot-level maintenance (McCall 1988).

While the end-result has always been positive, getting to that end is not always easy. For instance, the Army Training and Doctrine Command (TRADOC) headquarters, which was assigned the task of developing and implementing LOGMARS uses in installation property accountability, had many problems to overcome in learning how to use bar-coding equipment (McCall 1988).

Determined to overcome obstacles, TRADOC scheduled special training sessions for personnel in the property division. After training, computer equipment was strategically placed for easy access to all personnel. To save time, contractors performed the laborious tasks of creating bar-code labels and conducting the associated inventory. New labels were attached to an issue document and sent to the warehouse where they were affixed to the items.

The end-result is that the use of LOGMARS has greatly contributed to the elimination of TRADOC's excess non-recorded property, which had been a long-standing problem. National stock numbers and commercially procured items are no longer misidentified. The two most important and immediate benefits are increased *speed* and *accuracy* in conducting required inventory. Much time is saved with a hand-held computer, decoder, and laser gun set. Not only has LOGMARS decreased the work load for property book personnel but has significantly improved accuracy of property accountability at TRADOC.

There are, naturally, difficulties and obstacles to a full implementation of this program as there would be for any new technology still in its infancy. First, there is the unfamiliarity. Also, not all computers are equally adept at handling bar codes. We may have standardized bar coding but we have not yet done so for computers or the supporting software.

DEH Applications

Historically, installation Directorates of Engineering and Housing (DEHs) have used manual records to manage their maintenance, repair and minor construction equipment fleets. Accuracy and quality of these records were totally dependent on personnel filling out forms, for whom administrative responsibilities were secondary to their main jobs. Poor record keeping often made it difficult to decide on shop operations and personnel allocation to specific jobs. The incomplete inventory of repair parts often resulted in a shortage of stock supplies. Furthermore, preventive maintenance was often off schedule, overlooked or unnecessarily duplicated.

The number of applications of bar coding is almost limitless. While it is only natural to link parts inventory with bar coding first, this method can be used for recording when the parts are issued, when and how they fail, and ultimately as a reminder for scheduling other necessary maintenance. For example, a vehicle may be brought in for a tune-up. A quick pass over the bar code would bring up the entire maintenance record of the vehicle and self-generate any other required maintenance. A cumulative tally of all parts used in maintenance would be available, triggering a threshold order for parts in the inventory projected to be depleted.

The end-result is that the use of LOGMARS has greatly contributed to the elimination of TRADOC's excess non-recorded property, which had been a long-standing problem.

Fort Lee, Va., was selected as a test site for a "paperless" system which uses bar code readers as the primary input device. The five mechanics in the Heavy Equipment Shop were given "wands" that can read, record, and time-date stamp all of their transactions. Data tracking the receipt and execution of job orders, work performed, parts and fuel used, and dispatching of vehicles are collected into a computer run by an equipment specialist.

So far, results of the test at Fort Lee have been outstanding. Historical paper records and the backlog of preventive maintenance have been virtually eliminated. Bar coding has done away with the keying in of data, while dramatically improving accuracy at the same time. Mechanic productivity has improved by about 20 percent and, with preventive maintenance under control, there are fewer breakdowns of equipment. Duplication of preventive maintenance done as part of a major repair, and again soon after as a part of scheduled performance maintenance, has disappeared. Equipment usage records are monitored and repair histories are reviewed before turning in equipment. Total parts inventory has decreased by 50 percent and only the fast moving parts identified by the system are stocked. With the cross-referencing of parts, a necessary item can be identified without actually bringing the item to the shop. Most importantly, now that need for parts can be projected more accurately, parts can be ordered at volume discounts from GSA at a savings of 40-60 percent.

The paperless system used at Fort Lee was installed and implemented with contract support in approximately 1 month. Other systems were installed by DEH personnel without outside assistance at Fort Hood, Texas; Fort Riley, Kan.; and Fort Meade, Md. (CERL 1988).

Its users firmly believe that bar coding is as close as you can get to a perfect system today. Various forms of self-checking are built into the code structure of bar-code formats, making the input error-free and transposition of data a thing of the past. Each transaction is user identified along with the date and time so that the audit trail is there, if necessary.

Another area where bar codes are being implemented and tested by the Army is quality assurance inspections. Measuring satisfactory performance relating to Commercial Activities (CA) on Army installations has always been essential. However, methods currently in use require the Quality Assurance Evaluator to spend significant time and effort on inspections.

For this reason, the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (USACERL) developed an evaluation system specifically for use with CA contracts which includes inspection procedures, worksheets, checklists, and measurement devices. Checklists include bar codes for all inspection criteria, locations and evaluations. A recording bar-code reader is used to document inspection activities, and a microcomputer data base management software program is used to download the bar-code reader's memory each day. Special remarks can be recorded on a microcassette audio tape and later transcribed. The microcomputer can then generate all reports of missed activities, unsatisfactory performance, and even a trend analysis of contractor performance in addition to bar-code reader assignments.

Bar-code readers can increase productivity of quality assurance evaluators and help improve management of the CA contract for real property maintenance activities, while providing more control of the contract and reducing expenditures for work contracted but not carried out. This system was tested at the Rock Island Arsenal in the inspection of custodial services and is scheduled for 15 additional applications in the areas of utilities operation and maintenance, maintenance of other real property, and engineering support.

> Lighter, smaller and less expensive, the bar-code equipment available today can interface with almost any type of computer.

Prospects

The bar-code industry is continually being refined by the manufacturers and developers of bar-code equipment and technology. Lighter, smaller and less expensive, the bar-code equipment available today can interface with almost any type of computer. Many advances in bar codes are the result of responses to specific needs and demands of industry or specific applications, all of which should speed up their widespread use (Czaplicki 1988).

For example, a recent development in bar-code size resulted from a need to have more information encoded in less space. Electronics and health care industries were finding it difficult to place bar codes on some of their smaller parts and supplies. Many of these objects were too small to accommodate a bar-code label. As a result, Code 49, a two-dimensional symbology that utilizes 2-8 adjacent rows of bars and spaces instead of 1 row, was developed to solve this problem. Code 49 is capable of holding the same information as a Code 39 symbol but in one-sixteenth of the space.

Another example is the development of smaller and lighter computers with attached bar-code scanners. This move stemmed from the need to collect data in remote locations which could only be reached by personnel carrying portable terminals. Today, software packages are usually customized to meet the needs of an industry and its specific applications.

Yet another innovation will provide stores with an efficient and effective method of preventing shoplifting. The printed bar-code label will include a built-in, anti-shoplifting signal that will be deactivated when laser scanners read the bar code during checkout. This method will be less expensive to use and easier to handle, not to mention less time-consuming during the sale than the currently used "clips" directly attached to clothing.

Future scheduled Army projects involving bar codes include a work proposal to integrate bar-code technology into the facilities engineering supply function, where the real property maintenance mission at U.S. Army installations must be improved to be as cost-effective and efficient a supply system as possible. The Facility Engineer Supply System (FESS) needs to be substantially upgraded. Current procedures are such that much of the data is lost and entered incorrectly and stored in FESS and the Integrated Facilities System (IFS). Many of these procedures require information to be recorded at the point of origin. For this reason, data is often stored in a format not conducive to retrieval, resulting in unacceptable delay costs and absence of inventory accountability. A bar-code data entry system for collecting supply data for FESS and other interfaced data systems would greatly improve cost effectiveness and responsiveness of the facilities engineering supply function.

With the elimination of human-made errors, significant savings in time and money can occur as a result of bar-code implementation. The bar-code equipment of today can interface with virtually any type of computer. Developers of bar-code equipment and technology are continually striving to address specific requests and needs of

 (Continued from page 34)

their users and whole industries and, as a result, are making great advances in the progress of the bar-code industry.

Let us take up the challenge of expanding the implementation of this vital system in all areas of our armed forces' missions.

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always make the difference between success and failure in any systems acquisition program.

Considerable effort is still required to integrate the knowledge-based curriculum with the opportunities afforded by the scenarios for practice and application by the students. However, the Defense Systems Management College is confident that the organizational simulation concept will bridge the gap between awareness and successful application of critical acquisition knowledge and management skills in the preparation of military officers and civilians for key management positions in Defense acquisition.

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MODIFICATIONS AND EXTENSIONS: APPLYING THE

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The learning curve is an essential tool in weapon systems program management. It is used in cost estimation, proposal analysis, and contract negotiation. The concept is well known to those involved in program management, but the application of its formulas in a variety of acquisition-related decisions is not well understood. Compounding the problem is the paucity of data, necessitating modification of the basic learning-curve formula for application. The purpose of this paper is to provide a comprehensive discussion of the modifications and extensions of the basic learning-curve formula to serve as a handy reference source for those who must deal with the learning curve in various acquisition-related decision scenarios.

Cumulative Average Cost Model Vs. Incremental Unit Cost Model

There are two different versions of learning curve: the *cumulative average cost model* (a.k.a. *Wright's Model*) and the *incremental unit cost* model (a.k.a. *Crawford's Model*). The distinction between the two models has been discussed in an earlier paper.[1] We will limit the discussion to the notational difference between the two models to facilitate the numerical illustration later in the paper.

The same standard learning-curve formula is used by Wright and Crawford to formulate the decrease of cost at a constant rate, r, when the quantity is doubled:[2]

$$y = ax^b \qquad \text{(Eq. 1)}$$

where:

a = the theoretical first unit cost, and

b = the learning curve exponent, measured as follows:

$$b = \log(r)/\log(2)$$

The meanings of y and x, however, are different for the two models:

	Wright's Model	Crawford's Model
y =	cumulative average costs of each of the x cumulative units produced, and	the incremental unit cost of the xth unit produced, and
x =	the cumulative number of units produced.	the algebraic midpoint of a particular production lot

Table 1 shows a numerical example for contrasting these two models. This is, of course, a contrived example for illustrative purpose only. Actually, cost data rarely fall on the curve. For the moment, let's focus on the first two columns only and assume that the cost data (Column 2) are extracted from the job-order cost system. The example assumes a first unit cost of $100,000, an 80 percent learning rate, and no price level change. The incremental cost of producing each successive unit is shown in Column 2. However, production is typically done on a batch basis. Even for expensive products such as aircraft, it is too costly to track the cost of producing each successive unit. Therefore, data available for analysis from a job-shop accounting system used by all contractors would most likely resemble the yearly summary total figures as shown in the first two columns of Table 1 (e.g., $631,537 for the first 10 units).

Based on the incremental unit cost data, we may derive the cumulative average cost figures, as shown in Column 3. Note that the incremental unit cost decreases at the 80 percent rate for every doubling of quantity, but cumulative average cost decreases at a variable rate.

If the 80 percent learning rate applies to the cumulative average cost as observed by T. P. Wright, the cost decrease pattern would resemble Column 4 of Table 1, which reflects a learning rate of 80 percent for cumulative average cost when cumulative production quantity is doubled. To maintain this constant rate of decrease in the cumulative average cost, the incremental unit cost also decreases, but at a variable rate, as shown in Column 5.

To contrast the difference between Wright's model and Crawford's model, we can now determine the values of x and y for each model as follows:

	Crawford's Model		Wright's Model	
	y	x	y	x
1986	$63,154	4.1	$63,154	10
1987	$39,955	17.3	$49,234	25

Note that the x-y coordinates for each yearly production lot are different. Under the *cumulative average cost model*, the average cost for *each* of the first 10 units produced is $63,154 and the average cost for *each* of the first 25 units produced through 1987 is $49,234 ($1,230,863 of total cost incurred in 1986-1987 divided by the total quantity of 25 units). Under the *incremental unit cost model*, the $63,154 average cost in 1986 is approximately the same as the incremental cost of producing the 4th unit, and the $39,955 average cost in 1987 is about the same as the incremental cost of producing the 17th unit. The 4th and 17th units are called the *algebraic midpoints* (or *lot midpoints*) for their respective lots.

LEARNING CURVE FORMULA

Shu S. Liao

TABLE 1. HYPOTHETICAL COST DATA FOR THE FIRST 25 UNITS

	CRAWFORD'S MODEL*		WRIGHT'S MODEL**	
(1) Unit Produced	(2) Incremental Unit Cost (80% rate)	(3) Cumulative Average Cost	(4) Cumulative Average Cost (80% rate)	(5) Incremental Unit Cost
1986:				
1st	$100,000	$100,000	$100,000	$100,000
2nd	80,000	90,000	80,000	60,000
3rd	70,210	83,403	70,210	50,631
4th	64,000	78,553	64,000	45,369
5th	59,564	74,755	59,564	41,819
6th	56,168	71,657	56,168	39,191
7th	53,449	69,056	53,449	37,133
8th	51,200	66,824	51,200	35,457
9th	49,295	64,876	49,295	34,055
10th	47,651	63,154	47,651	32,855
Total 10	$631,537			
1987:				
11th	46,211	61,613	46,211	31,812
12th	44,935	60,224	44,935	30,893
13th	43,792	58,960	43,792	30,075
14th	42,759	57,802	42,759	29,338
15th	41,820	56,737	41,820	28,671
16th	40,960	55,751	40,960	28,061
17th	40,168	54,834	40,168	27,502
18th	39,436	53,979	39,436	26,986
19th	38,755	53,178	38,755	26,507
20th	38,121	52,425	38,121	26,061
21st	37,527	51,715	37,527	25,645
22nd	36,969	51,045	36,969	25,255
23rd	36,444	50,410	36,444	24,888
24th	35,948	49,808	35,948	24,542
25th	35,478	49,234	35,478	24,215
Total 15	$599,326			

* *Crawford's model implies that incremental unit cost decreases by a constant rate* (Col. 2) while cumulative average cost decreases by a variable rate (Col. 3).

**Wright's model implies that cumulative average cost decreases by a constant rate (Col. 4) while incremental unit cost decreases by a variable rate (Col. 5).

Incremental Unit Cost Model and Algebraic Lot Midpoint

Although the cumulative average cost model was developed first, the unit cost model has become the most widely used model. An Air Force study shows that 92 percent of respondents used the unit cost model.[3] The advantages for using the incremental unit cost theory have been discussed in other papers and will not be repeated here.[4]

Before one can apply the unit cost theory, the algebraic midpoint of each lot must be computed. The algebraic midpoint of each lot is defined as the point where the estimated production cost or hour on the curve equals the average for the entire lot. In other words, the incremental cost of producing this particular unit times the number of units in the lot should equal the total cost of the lot. Using Table l data for example, the algebraic midpoint for the 1986 production lot of 10 units is 4.12th unit. The incremental cost of producing 4.12th unit is:

$$y_{4.12th} = 100000 \bullet 4.12^{(-.3219)} = 63{,}396$$

which is the average cost for the 10 units in the lot (difference due to rounding).

Determining the Algebraic Midpoint

The algebraic lot midpoint can be determined by using the following equation:[5]

$$K = \left\{ \frac{L(1+b)}{N_2^{1+b} - N_1^{1+b}} \right\}^{-1/b} \qquad \text{(Eq. 2)}$$

Where:

K = algebraic lot midpoint,
N_1 = first unit in lot minus 0.5,
N_2 = last unit in lot plus 0.5,
L = lot quantity, and
b = exponent of the slope.

Eq. 2 shows that the algebraic lot midpoint is a function of lot size (**L**) and the learning rate (**b**). This does not present a problem if the learning rate is known and the objective is to estimate future costs or resource requirements. For example, if 20 more units beyond the 25 units shown in Table 1 are to be produced in 1988, the algebraic lot midpoint for the third lot is:

$$K = \left\{ \frac{20(1-0.322)}{45.5^{.678} - 25.5^{.678}} \right\}^{1/.322} = 34.87$$

The projected cost for this unit can be directly determined by using Eq. 1:

$$y = 100{,}000 \bullet 34.87^{(-0.322)} = \$31{,}866$$

Deriving the Learning Curve

A problem arises if the learning curve is unknown and must be derived from historical data, as is the case in many weapon system programs. As Eq. 2 shows, the algebraic midpoint cannot be determined unless we know the learning rate, which, in turn, requires lot midpoints for input. To solve this dilemma, an expedient procedure is widely used by practitioners to approximate the algebraic midpoint. Since the algebraic lot midpoint is much more sensitive to lot size than to the learning rate, especially for small lot size, a quasi-algebraic midpoint (A) can be computed by ignoring the learning rate:

First Lot:

$$A = \frac{L+1}{3} + 0.5 \qquad \text{(Eq. 3)}$$

Subsequent Lot:

$$A = \frac{L}{2} + \text{Sum of All Preceding Lots} \qquad \text{(Eq. 4)}$$

Eq. 3 and Eq. 4 provide a satisfactory approximation of algebraic midpoint when the lot size is relatively small. However, using this quasi-algebraic midpoint for cost estimation can lead to significant distortion of estimated costs. Therefore, the following iterative procedures should be followed to ensure the accuracy of estimated costs:

1. Use Eq. 3 and Eq. 4 to approximate the algebraic lot midpoint, A, for each lot.

2. Substitute the approximate midpoints into Eq. 1 and determine the approximate learning rate.

3. Use the approximate learning rate obtained from Step (2) to recompute the algebraic midpoints, Ks, using Eq. 2.

4. Use the new midpoints, Ks, obtained from Step (3) and recalculate the learning rate.

5. Compare the results of Steps (2) and (4). If the difference between the two learning rates is less than two percentage points, the learning rate from Step 4 is reliable and can be substituted into Eq. 2 for estimating purpose. If the difference is greater than or equal to two percentage points, Steps 3 through 5 are to be repeated, with each successive new learning rate as the input for midpoint recalculation.

We will use the cost data in Table 2 to illustrate these iterative procedures. The data pertain to the eight production lots of the Sparrow AIM-7F Missiles program. The unit cost figures have been adjusted to constant dollars. The procedure to determine the learning curve from these raw data is explained below:

Step 1: Since the learning rate is unknown, it is necessary to use Eq. 3 and Eq. 4 to determine the approximate algebraic midpoint for each lot. The results are shown in Column (4) of Table 2.

TABLE 2. DERIVING UNIT CURVE FROM LOT DATA

LOT # (1)	LOT SIZE (2)	UNIT COST ($1,000) (3)	FIRST ITERATION: APPROXIMATE MIDPOINT (A) (4)	FIRST ITERATION: ALGEBRAIC MIDPOINT (K) (5)
1	100	415.80	34.2	30.9
2	225	212.00	212.5	198.1
3	600	111.60	625.0	589.9
4	880	94.70	1365.0	1331.6
5	1110	75.00	2360.0	2329.7
6	1400	65.10	3615.0	3583.7
7	900	62.10	4765.0	4755.6
8	1144	53.50	5787.0	5774.3
		b=	−.3955	−.3874
		Learning Rate=	76%	76.5%

Step 2: The y term of Eq. 1 is represented by the lot unit cost data shown in Column 3. The x term is, for the moment, represented by the approximate midpoints in Column 4. Both columns are then converted to the logarithmic scale to obtain a linear regression equation. The resultant b value is shown at the bottom of Column (4).

Step 3: *The b value obtained from Step 2 enables us to* use Eq. 2 for a more accurate determination of the algebraic lot midpoints. Column (5) shows the recalculated lot midpoints.

Step 4: The x term of Eq. 1 is now replaced by the newly determined algebraic midpoint and a new linear regression equation is computed. The result is shown at the bottom of Column (5).

Step 5: Comparing the learning rates at the bottom of Columns (4) and (5), we found the difference to be very small (76% vs. 76.5%). We can repeat Steps 3 and 4, but the improvement in accuracy will be negligible. Therefore, we can reliably use the 76.5 percent learning rate to estimate future missile cost by using Eq. 2 and Eq. 1.

It is rare that an analyst has to go through more than one iteration to arrive at a reliable learning rate. There are two reasons why the two expedient equations work so well. The first is that the algebraic midpoint is much more sensitive to the lot size than to the learning rate, i.e., ignoring the latter does not result in a significant distortion of midpoint. Second, the learning effect flattens out after the first few lots and the approximate midpoints are almost as good as the algebraic midpoints.

Extensions and Applications of Wright's Model

We will now discuss the extensions of the basic learning curve model and illustrate their applications in various program management decision scenarios.

Determining Learning Rate from Two Data Points

There are cases when only two observations of cost/quantity relationship are available and determination of the learning curve (*albeit imprecise*) is desirable, sometimes even necessary. Under this circumstance, Eq. 5 may be used to arrive at an approximate learning rate:

$$b = \frac{\text{Log}(y_2/y_1)}{\text{Log}(x_2/x_1)} \qquad \text{(Eq. 5)}$$

where:

y_1 = average cumulative unit cost at point 1,
y_2 = average cumulative unit cost at point 2,
x_1 = cumulative production quantity at point 1, and
x_2 = cumulative production quantity at point 2.

Let us use Table 1 data to illustrate the application of this modified learning curve equation. Suppose that we have information on the average cumulative unit costs only at two production points: (1) the end of 1986, 10 units @ $47,651 and (2) the end of 1987, 25 units @ $35,478. What is the learning rate reflected between these two points?

Solution:

$$b = \frac{\text{Log}(35478/47651)}{\text{Log}(25/10)} = -0.3219 \ (r = 80\%)$$

A few words of caution are in order for using this equation. Unless the two points are representative of the true relationship, i.e., the two points are on or very close to the true relationship line, the resulting learning curve may be misleading.

Deriving Theoretical First Unit Cost

In many instances the learning rate is agreed upon through negotiation instead of a regression analysis of historical data. In this case it is necessary to estimate the theoretical first unit cost before Eq. 1 can be used. If we have information of the average cumulative unit cost at any specific cumulative quantity point, we can derive the theoretical value of the first unit, **a**, by using the Eq. 6:

$$a = y/x^b \qquad \text{(Eq. 6)}$$

This equation is in essence a rearrangement of the basic learning curve formula (Eq. 1). Let us assume that the government and the contractor agreed on an 80 percent learning rate, and that the cumulative average cost for the first lot of 10 units is $47,651. What is the theoretical first unit cost?

Solution:

$$a = \frac{47{,}651}{10^{(-.3219)}} = \$100{,}000$$

Determining the Total Costs for Producing x Cumulative Units

Since the basic learning curve formula (Eq. 1) tells us the average cumulative unit cost when x cumulative units are produced, the total cost for the same x cumulative units is simply the product of the average (y) and the cumulative number of units produced (x), as shown below:

$$T = y \bullet x = ax^b \bullet x = ax^{(b+1)} \qquad \text{(Eq. 7)}$$

where: T = total cost or labor hours.

Determining the Incremental Cost for Producing Additional Units

Eq. 7 can be used to determine the incremental cost or hours for producing additional units. To see how we can apply this formula, let us assume that we have determined the first unit cost to be $100,000 and the learning curve to be 80 percent. What would be the *incremental* cost if government decides to buy 15 more units in Lot #2, after buying 10 units in Lot #1?

Solution: Total cost for the first 25 units

$\$100{,}000 \bullet 25^{(-.3219+1)}$	$887,040
Total cost for the first 10 units	
$\$100{,}000 \bullet 10^{(-.3219+1)}$	476,540
Incremental cost for 15 units	$410,500
@ $27,367 per unit	

To illustrate another application of the formula, let us further assume that, after 5 units were produced and delivered, the remaining contract was cancelled. The price of the 5 units delivered has to be renegotiated (because it would cost more to produce the first 5 units than the second 5, if the learning curve is in effect). What should be the incremental cost for the first 5 units delivered?

Solution: Total cost for the first 15 units

$\$100{,}000 \bullet 15^{(-.3219+1)}$	$627,346
Total cost for the first 10 units	
$\$100{,}000 \bullet 10^{(-.3219+1)}$	476,540
Incremental cost for 5 units	$150,806
@ $30,161 per unit	

Erroneous Application

A common error in applying the learning curve theory is the attempt to derive the incremental unit cost from the cumulative average cost formulation using the marginal cost concept in economics. The marginal unit cost function, **M**, is obtained by "differentiating" the total cost function, **T**:

$$M = \frac{dT}{dx} \, (b+1)ax^b \qquad \text{(Eq. 8)}$$

To illustrate that this "marginal" function (Eq. 8) can distort the incremental unit cost of producing the specific (xth) unit, let us use the numerical example in Table 1 again. Since the base data were constructed with a = $100,000 and b = −0.3219 (80% learning rate), we may compute the "marginal" cost of producing the second unit using Eq. 8 as follows:

$$M_2 = (1-.3219)(100{,}000)2^{-.3219} = \$54{,}249$$

Note that the incremental unit cost for producing the 2nd unit should be computed as follows:

Total cost for the first 2 units	
$T_2 = \$100{,}000 \bullet 2^{(-.3219+1)}$	$160.000
Total cost for the first unit	
$T_1 = \$100{,}000 \bullet 1^{(-.3219+1)}$	100,000
Incremental cost for the 2nd units	$ 60,000

The incremental unit cost shown here is the same as Column 5 of Table 1. To illustrate the fallacy of using Eq. 8 to derive the incremental unit cost from the cumulative average formulation, we will compare the true incremental unit costs (Column 5, Table 1) to the "marginal costs" for the first eight units.

x	Cumulative Average Cost	Total Cost	Incremental Unit Cost	"Marginal" Cost
1	100,000	100,000	100,000	67,810
2	80,000	160,000	60,000	54,249
3	70,210	210,631	50,631	47,611
4	64,000	256,000	45,369	43,400
5	59,564	297,819	41,819	40,392
6	56,168	337,010	39,191	38,090
7	53,449	374,143	37,133	36,246
8	51,200	409,600	35,457	34,721

This anomaly does not invalidate the axiom that the first derivative of the total cost curve is equal to the marginal cost of the additional unit produced. However, this example illustrates the difference and incompatibility between the two competing learning curve models. The incompatibility is caused by the fact that, while the basic functional equation is the same, the definitions of **y** and **x** are different. Using the first derivative (Eq. 8) of a total cost function (Eq. 7) under the cumulative average model to derive the incremental unit cost is equivalent to changing the definition of **y** (from cumulative average to incremental) without changing the definition of **x**. The reader is reminded that failing to recognize this subtle difference in the definition of **x** can lead to much more serious errors than shown above. If the incremental cost is the focus of the analysis, then the unit cost theory is the logical choice.

Extensions and Applications of Crawford's Model

As discussed earlier, the same basic equation is used in Wright's cumulative average model and Crawford's incremental unit cost model, but the definitions of **x** and **y** are different. To emphasize the fact that the cumulative quantity, **x**, in Crawford's learning curve refers to the lot midpoint, **K**, we will use Eq. 9 to represent the basic formula for Crawford's model:

$$y = aK^b \qquad \text{(Eq. 9)}$$

where **K** represents the algebraic midpoint of a lot. Eq. 9 is the same as Eq. 1, except **x** is replaced by **K**.

Crawford's model also has several variant formulas for use under different scenarios.

Determining Learning Rate from Two Data Points

In major system acquisition, there are cases when only the average costs of two production lots are available and a learning curve is to be derived from these two observations. The following equation is a modified version of Eq. 5, reflecting the need to use the algebraic midpoint of each lot as the cumulative quantity:

$$b = \frac{\text{Log}(y_2/y_1)}{\text{Log}(K_2/K_1)} \qquad \text{(Eq. 10)}$$

where:

y_1 = average unit cost of Lot 1
y_2 = average unit cost of Lot 2,
K_1 = cumulative quantity at Lot 1 midpoint, and
K_2 = cumulative quantity at Lot 2 midpoint.

Using the missile data in Table 2 for example, let us pick the two production lots closest to the least square line (1976 and 1980) to get a rough measure of the learning curve. The lot midpoints and average costs are:

	Lot midpoints	Average Unit Costs
1976 (Lot #4)	1,331.6	$94,700
1980 (Lot #8)	5,774.9	$53,500

By using Eq. 10, we can compute the learning curve exponent with these two data points:

$$b = \frac{\text{Log}(53{,}500/94{,}700)}{\text{Log}(5{,}774/1{,}331)} = -0.3891$$

This value is very close to the result we got when all available data points were used (i.e., −0.3874).

Deriving Theoretical First Unit Cost

If the learning curve is not derived from a regression analysis of historical data, the theoretical first unit cost, **a**, must be determined before we can use the learning curve equation for cost estimating purpose. We may determine the theoretical first unit cost for the learning curve by rearranging Eq. 9 as follows:

$$a = \frac{y}{K^b} \qquad \text{(Eq. 11)}$$

The equation shows that the first unit cost can be determined if the learning rate and the data for one production lot are available. Take the Sparrow Missile case for example; if the learning rate is agreed upon through negotiation or established by means of Eq. 10 instead of the basic learning curve equation (Eq. 9), we can use the data for Lot #4 (1976) to derive the theoretical first unit cost as follows:

$$a = \frac{94{,}700}{1{,}331.6^{-0.3891}} = \$1{,}556{,}127$$

Determining Incremental Cost of Producing a Specific Unit (xth Unit)

Crawford's model directly measures the incremental unit cost of any specific unit. Therefore, Eq. 9 will serve this purpose if the specific (xth) unit is substituted into the equation.

There is an alternative equation that the incremental unit cost can be computed:

$$y = ar^{(\text{Log}K/\text{Log}2)} \qquad \text{(Eq. 12)}$$

where r refers to the learning rate (not exponent). Let us use the data in Table 1 for illustration. Since the first unit cost is $100,000 and the learning rate is 80%, the unit cost of producing 32nd unit may be estimated as follows: (difference due to rounding)

Eq. 9 $\quad y = 100{,}000 \bullet 32^{-.3219} = \$32{,}771$

Eq. 12 $\quad y = 100{,}000 \bullet 0.8^{\text{Log}(32)/\text{Log}(2)}$

$\qquad = 100{,}000 \bullet 0.8^{5} = \$32{,}768$

Note that in Eq. 12 the exponent, LogK/Log2, represents the number of times the production quantity has doubled when the xth unit is produced. For example, when the 32nd unit is produced, the doubling of quantity has taken place 5 times.

Determining Incremental Cost of Producing An Additional Lot of Q Units

This is probably the most common scenario for using the learning curve as a cost-estimating tool. The straight forward method of determining the incremental cost or labor hours for an additional lot is to determine the algebraic midpoint of the lot (Eq. 2) and substitute the midpoint value into either Eq. 9 or Eq. 12. Again using Table l data for our example, if we assume that 20 more units beyond the 25 units produced in 1986 and 1987 are to be produced in 1988. The algebraic lot midpoint for this lot will be 34.87. The average cost for producing the 1988 lot of 20 units equals the unit cost of producing 34.87th unit. Therefore the incremental cost for the lot may be computed below: (true value is $637,494, differences due to rounding)

Using Eq. 9:
$20y = 20 \bullet 100{,}000 \bullet 34.87^{-.3219} = \$637{,}551$ or

Using Eq. 12:
$20y = 20 \bullet 100{,}000 \bullet .8^{(\text{Log}34.87/\text{Log}2)} = \$637{,}487$

Alternatively, we may bypass the algebraic lot midpoint calculation and directly compute the incremental cost for the lot of Q units with Eq. 13:

$$Qy = \frac{a}{1+b}\left(N_2^{1+b} - N_1^{1+b}\right) \qquad \text{(Eq. 13)}$$

Where: N_1 = first unit in lot minus 0.5,
N_2 = last unit in lot plus 0.5,

Thus, the incremental cost for the 20 units to be produced in 1988 can be estimated as follows:

$$20y = \frac{100{,}000}{1 - 0.3219}\left(45.5^{.6781} - 25.5^{.6781}\right) = \$637{,}568$$

Let us illustrate the application of these equations in another scenario. Suppose that the government cancelled the contract after 10 units were delivered. This action calls for renegotiation of the price since it would cost more to produce the first 10 units than the second 10, if the learning curve is in effect. The incremental cost for the first 10 units produced in 1988 is:

$$10y = 10 \bullet 100{,}000 \bullet 30.32^{-.3219} = \$333{,}420$$

Determining Costs for A Lot When Only Learning Rate And Average Costs of Another Lot Are Known

It is not unusual that the lack of data does not allow us to derive a learning curve equation by means of regression analysis. However, given a learning curve, either through negotiation or relying on the past experience, we may determine the average unit cost or hours of any specific lot if the average unit cost of another lot is available. Eq. 14 is derived for this purpose.

$$y_2 = y_1 \left(\frac{K_2}{K_1}\right)^{b} \qquad \text{(Eq. 14)}$$

where:

y_2 = the average unit cost of the lot to be predicted,
y_1 = the average unit cost of the lot with known average cost,
K_2 = the midpoint of the lot to be predicted, and
K_1 = the midpoint of the lot with known average cost.

Using the Sparrow Missile case for example, if the government and the contractor agree on a 76 percent learning curve and the $94,700 per missile production cost for the 1976 contract (Lot #4), what would be the estimated unit cost for 1,144 missiles in 1980 (Lot #8) assuming the company would have produced 5,215 units prior to the 1980 contract?

Solution:

1976: Lot midpoint (K_1) = 1,331.6; y_1 = $94,700.

1980: Lot midpoint (K_2) = 5,774.3; y_2 = ?

$y_2 = 94{,}700(5{,}774.3/1{,}331.6)^{-.3959} = \$52{,}980$

Multiplying the $52,980 unit cost by the number of units in the lot, we can determine the total cost for the lot.

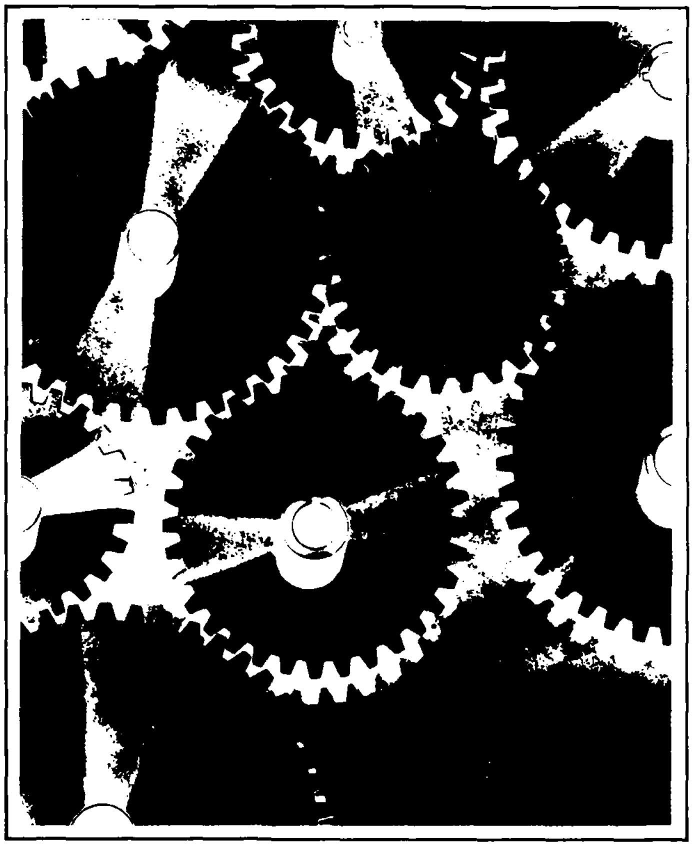
Concluding Remarks

The learning curve is an essential tool in defense systems program management. However, its application is characterized by the paucity of useable data, requiring modifications and extensions of the basic formula. This paper discusses 14 learning curve formulas that may be used in a variety of acquisition-related decision scenarios.

(See LIAO, page 91)

CASC EARLY-ON INVOLVEMENT IN THE ACQUISITION PROCESS

Debbie Horsfall



Do you know of acquisition programs that would benefit from the following, especially since they are freebies? Benefits include cost savings from: eliminating unnecessary research and development; providing better quality lists like bulk items, electronic support equipment, and hand tools; eliminating stocklisting of new items when items already exist in the inventory; eliminating the need to train personnel on new equipment; and eliminating the need for new operation and repair manuals. Also, there would be reduced production and delivery leadtimes; improved supportability, reliability and maintainability by using items with proven records; and enhanced competition in procurement by identifying additional sources for items of supply.

CASC Services

The Air Force Cataloging and Standardization Center (CASC) is in a unique position to assist in providing these benefits. We are an AFLC organization of 468 people, located at Battle Creek, Mich., and perform the following services.

Item Entry Control

We are controlling the number of items entering the Department of Defense inventory and reviewing existing items in the inventory to identify duplicate items of supply. The objective is to maintain the best spare-parts support for our weapon systems by using existing standard and preferred items already in the inventory as much as possible. In terms of items proposed to enter the inventory as the result of an acquisition, this means having the Equipment Specialist (ES) compare the characteristics of the proposed item with available Air Force and DOD assets. The Equipment Specialist then determines whether an existing item can be used.

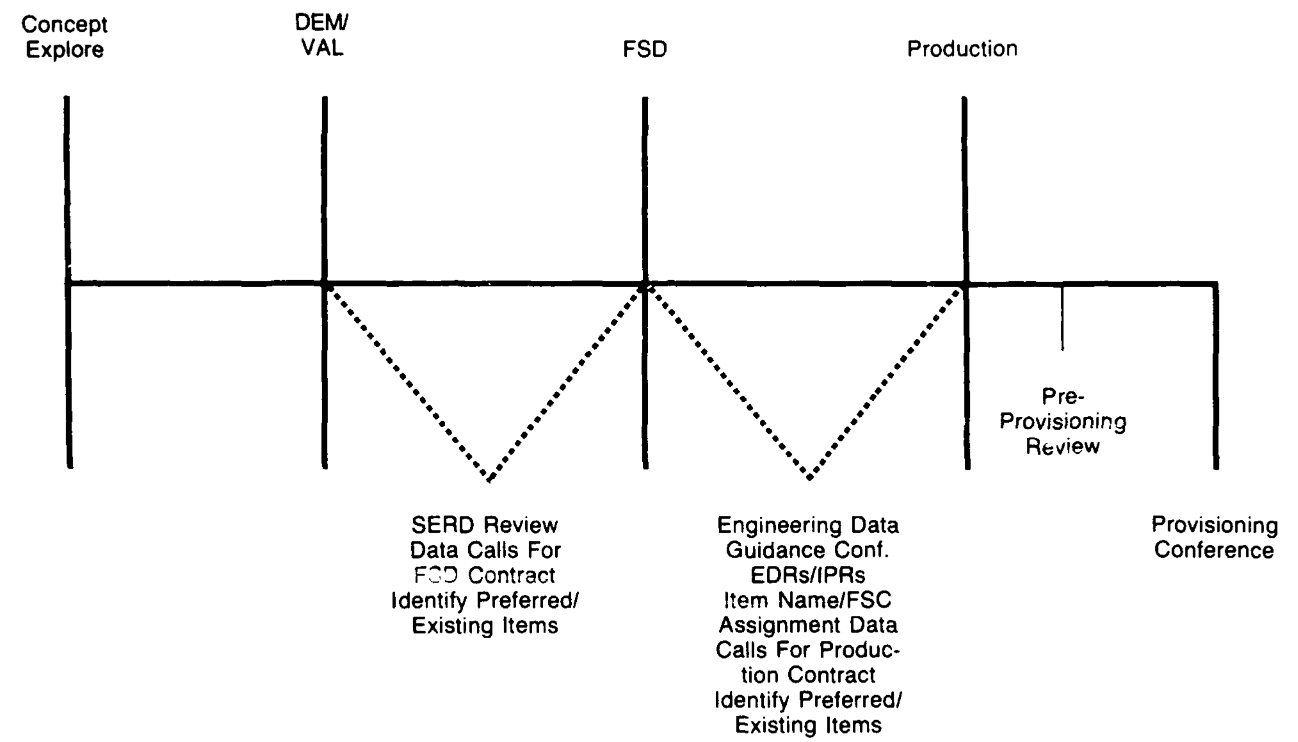
Review of Technical Data

This is for item identification and standardization requirements (form, fit and function) in accordance with MIL-STD-1561, DOD Provisioning Procedures. We analyze engineering data for adequacy, completeness/conformity to contract and DOD requirements (DoD-D-1000 and DoD-STD-100). In doing this review, we help the Air Force obtain an optimum data package for the system and follow-on support.

Assignment of Item Name and Federal Supply Classification

These provide a means of grouping items in a systematic arrangement based on common, related characteristics. It

FIGURE 1. ACQUISITION TIMELINE



serves several supply management needs such as standardization and assignment of the item manager.

The CASC now performs all of these functions after production contract award in conjunction with provisioning (see Figure 1). Moving from a previous post-provisioning mode to the current pre-provisioning mode has given the Air Force some gain. However, far more benefits will accrue by moving the same functions back into the demonstration/validation and full-scale development timeframes.

We are experimenting with specific programs, projects and actions to determine how we can provide the best support.

Small Intercontinental Ballistic Missile

Since September 1986, CASC and the Air Force Systems Command (AFSC) Ballistic Missile Office (BMO), have been working to get early involvement of cataloging and standardization in the acquisition process of the Small Intercontinental Ballistic Missile (SICBM). We reviewed the 1,200 common hand-tools on the SICBM tool list and found that 732 (62%) were not preferred items. Specifically, 602 stocklisted items could be substituted for 775 proposed non-stocklisted tools, thus preventing all the costs involved with bringing these new items into the inventory. An additional 130 stocklisted items were found to be preferred over 414 proposed stocklisted tools.

Action is underway to link the BMO Logistics Support Analysis (LSA) database (BMO-STD-77-6A) with CASC via the Logistics Management Information System (LMIS) at Ogden Air Logistics Center, Hill Air Force Base. By using Z-248 computers, we will receive the SICBM Logistics Support Analysis Record (LSAR) E and H Sheets (Support Equipment and Provisioning Parts List), make recommendations, and transmit this information back to the data base. This process will be expanded to the Rail Garrison Program.

The E sheets (Support Equipment Recommendation Data—SERDs) will be reviewed by us to ensure accuracy and completeness of the information. When Ballistic Missile Office receives this data from ASCONs (Associated Contractors) for formal coordination, we will review them first so that our recommendations for support equipment will be visible to all subsequent reviewers as preferred/standard items.

The H sheets (Provisioning Parts Lists) will be reviewed for:

—Item Name and Federal Supply Classification (FSC)

—Item Entry Control Data (stocklisted items, preferred parts, alternate sources) as soon as the lists enter the data base

—Technical data adequacy.

We were involved early in this acquisition by reviewing the Electronic Support Equipment List, Support Equipment Commonality List, and the Bulk Items List.

C-17

The CASC is involved early in the acquisition of the C-17. We attended an In Process Review (IPR) of engineering data to assist the Engineering Data Management Officer (EDMO). The purpose of IPRs is to ensure the contractor is meeting contractual obligations to the Air Force. Our participation has been beneficial to AFSC and AFLC.

(See HORSFALL, page 52)

PRODUCTIVITY IMPROVEMENT CAUSES CONSTANT CHANGE

(First of a Series)

John S. W. Fargher, Jr.

SSGT Lowell Gilstrap, USAF

In an earlier time (1970), it is interesting to note that in his stimulating and thought-provoking book, "Future Shock," Alvin Toffler discusses dealing with accelerating changes in technology and the environment. In 19 years, change has become the hallmark of the new high-technology manager as a "change master." The change master must be eternally vigilant to new customer requirements to guide new product development. The international environment is very competitive, requiring introducing many more products at a much faster pace, and a willingness to routinely and deliberately proliferate product design and engineering changes and create new services to meet weapons processes and plans for creating the environment for constant improvement in the future. He recognizes that drastic improvements, driven by always trying and evaluating changes to the process, are required if productivity and quality are to be improved sufficiently to compete in tomorrow's marketplace. The executive must drive the execution of change with a focus to customer requirements, learning how to become a world-class competitor. A long-term commitment to the new philosophy of constant, continuous improvement in quality and productivity is required.

A recent article in *Business Week* (June 6, '88) entitled, "The Productivity Paradox," relates the elusive payoff of automation, relating that GM has spent more on automation than the gross national products of many countries and has little to show for it. Although a few companies have prospered from automation, big gains from the automation of technology have not been achieved as originally envisioned. Automation, in and of itself, will not turn a company around. An orientation to integrate people and their better ideas into the organization, firm but fair management, and a commitment to a focused strategy process, and quality improvement and measurement of achievements are required. The change master must be a leader of people, not just the manager of resources. The keys to success are innovation, formal management processes, and leadership and decision orientation.

Introduction

There are several tools for changes. Primary is that of strategic/business planning. Results must be measured as a normal part of the business. Accounting must change its emphasis from cost accounting to managerial account-

ing to figure the real cost of operations. Incentive systems must be devised that reward worker participation in quality and productivity improvement. The cornerstone, however, is emphasis on the philosophy of continual quality and productivity improvement. This paper introduces each of these "tools for change," with subsequent papers detailing the productivity and quality improvement techniques, measurement methodologies, and Total Quality Management (TQM) philosophy, using the NAVAVNDEPOT at Cherry Point, N.C., as an example of lessons learned. The NAVAVNDEPOT Cherry Point has achieved the distinction of being awarded the 1988 Institute of Industrial Engineers Award for Excellence in Productivity Improvement, designated as the President's Productivity Improvement Program Quality Improvement prototype, and is the first organization within the Department of Defense to initiate Productivity Gainsharing organization-wide, *and is the first organization within the Department of Defense to receive Dr. Costello's plaque for outstanding achievement in the implementation of TQM.*

Strategic Business Planning

Technology improvements alone will not improve competitiveness. Managers have a greater requirement to focus on the business philosphies of long-term profitability and survival in the international marketplace. To accomplish this, common goals and measurable objectives must be established and plans of action with milestones executed as part of the organization's strategic/business plan. A strategic/business plan requires a detailed organization-wide analysis of all business activities to understand the key cost drivers, both value and non-value adding. The strategic/business plan must result in the development of an integrated long-range and short-term plan for change. Commitment to continuous improvement requires transformation of the corporate culture, adaptation of the organizational structures and alteration of the way in which managers think and deal with human resources. Strategic/business planning provides a holistic approach to establish the basis for productivity and quality improvement. The strategic/business planning process is detailed with examples from the NAVAVNDEPOT Cherry Point Strategic/Business Plan in another article entitled, "Planning for Change: Development of a Strategic Business Plan."

Total Quality Management

Total Quality Management is the centerpiece for employee participation in changes for constant improvement of productivity and quality. Total Quality Management is actually a philosophy that applies several techniques using employee involvement and participation, Statistical Process Control (SPC), group dynamics, and facilitization of team-building/team interaction, and structured management commitment and involvement. The payoff for TQM/SPC is the elimination of waste. Total Quality Management has the benefits of breaking down departmental special interests, replaced by optimizing for the total organization by sharing information, creating departmental integration, striving toward organizational unity, and concentrating on the long-term business. The NAVAVNDEPOT at Cherry Point has embarked on total emersion into TQM, and significant progress has been made in its implementation. Process analyses has been accomplished utilizing Process Action Teams (PATs). A complete TQM structure has been developed, SPC/TQM-trained personnel are available, and employee participation in the TQM process has been accelerated. Details of the initial implementation of TQM and "lessons learned" at NAVAVNDEPOT Cherry Point are presented in another paper entitled "Implementing Change through Total Quality Management." Progress achieved since then is detailed and new case examples presented in "Total Quality Management: Accelerating the Improvement of Quality and Productivity," another article in the series.

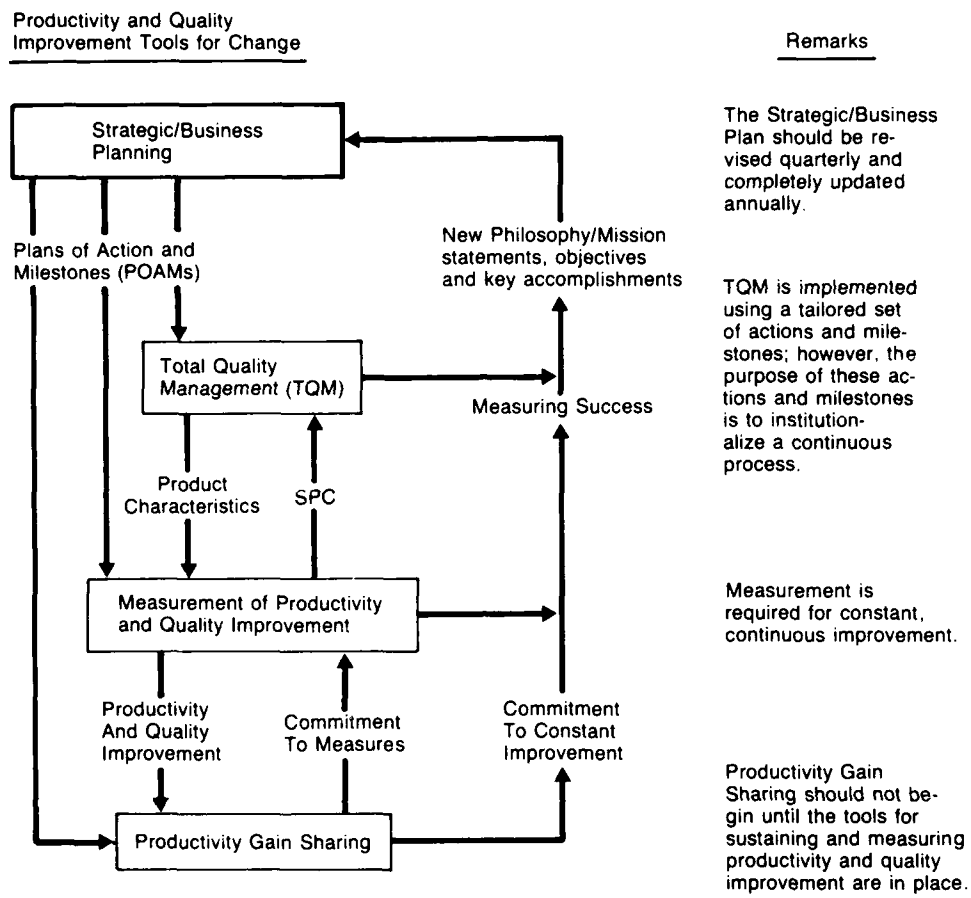
Accounting for Productivity And Quality Improvement

That which cannot be measured cannot be managed. While Statistical Process Control is one effective measurement technique, measurement of cost is the ultimate measure of productivity. A total quality management implementation matrix is the basis for measuring progress. This matrix is made up of the cost of products produced (e.g., at NAVAVNDEPOT Cherry Point this includes aircraft, engines, ground support equipment, and components); scheduled versus actual completions; and the number of Quality Deficiency Reports/Aircraft Deficiency Reports (QDRs/ADRs) received from customers. These data are readily available from the present Manufacturing Resource Planning (MRP-II) system. A local area network and distributed computing capability has been added to make the MRP-II data more readily available, and development and analysis of trends more automated. The analysis of cost of products produced helps to pinpoint areas where corrective action can have the greatest benefit (Paredo's law). Before this analysis can be complete, however, the "most nearly actual" cost to produce the product must be known. This cost must include direct labor, direct material, production indirect, and overhead. A description of the cost/management accounting system developed to give these costs is included in the article, "A Managerial Accounting Methodology for Measuring Productivity and Quality Improvement." Cost data are readily available from the financial management system; this data must be provided in a timely, readily understood manner to be useful in detecting trends as soon as an out-of-control situation is detected. Through TQM, the NAVAVNDEPOT management and work force intends to push for continuous cost improvements through process improvements that allow better utilization of material, equipment and facilities.

Productivity Gain Sharing

Productivity Gain Sharing is an employee involvement system designed to motivate employees to improve the productivity of their work group through better use of labor, material, etc. In addition, gain sharing provides a means of measuring specific areas of productivity and offers a mutual stake in the sharing of any increase to total organizational produc-

FIGURE 1. PRODUCTIVITY AND QUALITY IMPROVEMENT MODEL



tivity with all those responsible for the increases. The Productivity Gain Sharing Program is intended to encourage greater productivity through physical effort (working harder) and through process improvement (working smarter). It is anticipated most significant gains will be made in process improvement utilizing the TQM organization. A NAVAVNDEPOT Cherry Point Productivity Gain Sharing plan has been written with the intent of providing an appropriate award system/payout mechanism for these TQM efforts. The plan is a SHRED COST model with baseline data developed based on the average NAVAVNDEPOT cost performance for each of the previous quarters. Productivity gains are paid for each quarter that the facility exceeds this average. The baseline is updated each quarter with new quarterly data. Productivity Gain Sharing awards are paid upon increased productivity (i.e., decreased auditable costs). Payout is also based on meeting acceptable quality levels, defined as maintaining statistical process control of the quality index, and acceptable schedule production using a schedule index. An equal sharing (50 percent/50 percent) of savings between the activity and employees is based upon productivity increases in the baseline. The full model is described in another article entitled "Incentivizing Productivity and Quality Improvements through Productivity Gain Sharing," including measurement techniques. This paper describes the NAVAVNDEPOT experience using Productivity Gain Sharing including lessons learned during implementation. Productivity Gain Sharing has been initiated depot-wide, a first within the Department of Defense.

Developing the Productivity And Quality Improvement Model

There is a specific sequence required to obtain optimal benefits from a productivity and quality improvement philosophy even though, once started, each step builds not only on previous phases but provides integration among phases and/or reinforcement of the productivity and quality philosophy. Figure 1 provides the framework for sequencing-in application of techniques and philosophies. The critical point here is that an organization needs to begin by defining what is important to the operation before it begins improving productivity and quality on products that would not warrant concentrated commitment of resources. Measurement is critical; however, what is to be measured and the techniques to be used should be driven by the strategic/business plan and

statistical process control. Productivity Gain Sharing should not be implemented until the techniques and philosophy required for continuous improvement are implemented, measurement schemes are in place, barriers to communications are minimized, and progress has been made in the quality of work life and productivity and quality improvement.

Conclusions

The thesis of this article is that an organization, led by a "change master," can make the journey from marginal to world class; however, in doing so, that organization will have made profound changes in its corporate culture. The journey must be firmly rooted in evaluating the mission and objectives of the organization, analyzing the environment, evaluating alternatives, setting goals, and proceeding to plan and execute means to achieve desired results. The philosophy or logic underlying the journey is holistic in that it is based upon the theory of productivity and quality improvement, and uses those tools best suited for analysis of variances, that of statistical process/quality control. These tools provide unbiased process information relating to the production flow. Measurement of results must be purposeful. The iterative process must strive for constant change, growth, stimulation, and reframing, seeking to stop routinizing the state of the organization. The change master must not only take actions to create change but must inquire about what changes are needed, bringing co-workers along on the journey. The change master must be fully aware of co-workers, providing a purposeful path and usable tools for sojourners and encouraging the sojourners to cast off millstones and try new courses, while maintaining the purposeful journey.

Only the collision of current management theory and practice as found in world-class organizations can provide a road map for the journey. Without change-master-level leadership, however, developed through studying and applying management engineering theory considering the purposeful as well as holistic view of the organization, the journey never begins.

Mr. Fargher is the Management Controls Department Head and Comptroller at the Naval Aviation Depot, Cherry Point, N.C. He has been a Professor of acquisition/program management at DSMC.

HORSFALL

(Continued from page 48)

We attended a Technical Interchange Meeting (TIM) at the contractor's site. The purpose of this joint government and industry meeting was to provide an exchange of ideas and technical expertise between the aircraft manufacturer and the Air Force with the goal of providing optimum support of the aircraft. One concern was to ensure the use of Government Furnished Equipment as much as possible. Another was to ensure the most preferred items were being identified by the contractor for support equipment and to avoid proliferation of items in the inventory.

We are supporting the C-17 program with participation in the Resident Integrated Logistics Support Activity (RILSA). An equipment specialist and a senior supply cataloger are permanently assigned at the contractor's facility, Long Beach, Calif.

B-1B

We reviewed the B-1B Tool List provided by the contractor and determined that 1,304 (33%) of the 3,900 items no longer existed. Standard items were offered as replacements.

Tiger Tool Team

We are working with the HQ USAF/LEY chartered Tiger Tool Team (T3) to prepare a listing of tools that will be part of the Support Equipment Acquisition Management System. These tool lists are to be used to influence design of future weapon systems. This will avoid proliferation of unneeded tools in the supply system and, more importantly, on the flight line.

Data Call Review

We participate in the Data Call Review Process. A data call is the formal procedure used by the data management officer to identify data requirements for a given contract, program or project. We identify requirements applicable to our mission and make other recommendations. One major requirement is to ensure that Support Equipment Illustrations (SEIs) are bought on all support equipment contracts. This information is used to load the MIL-HDBK-300 Technical Information File (TIR). Another is to ensure that CASC is included on the Contract Data Requirements List for delivery of Supplementary Provisioning Technical Data.

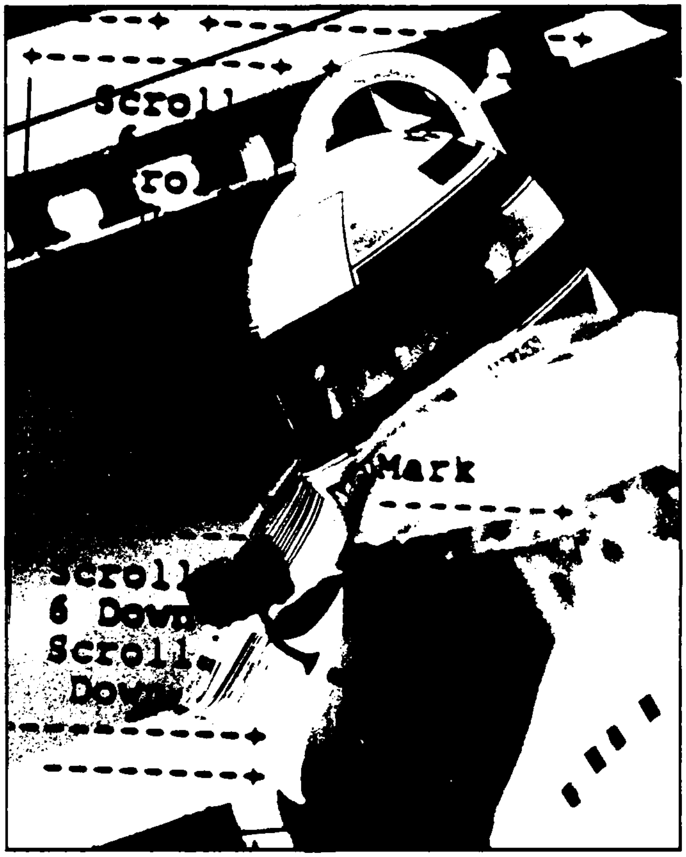
Engineering Data Guidance Conference

We are beginning to attend engineering data guidance conferences. This is a comfortable environment for us because it is an extension of our daily workload.

Moving into the earlier acquisition stages is a natural flow for cataloging and standardization, as well as an exciting challenge to our organization. If you feel we can make a contribution to a program you are working, contact us at Autovon 932-5761 or Commercial (616) 961-5761.

Mrs. Horsfall is a Program Manager in the Acquisition Programs Support Division, Policy, Procedures and Programs, Management Directorate, Air Force Logistics Command, Cataloging and Standardization Center, Battle Creek, Mich.

Lieutenant Colonel Bruce G. Luna, USAF



You've arrived at your new duty station and are given your first assignment by a new supervisor. This being your first exposure, you certainly want it to be a positive experience. You're told to pick up papers at the administration office, sign out keys to the motor pool vehicle, and take papers to another office on the other side of the base. You get the papers and pick up the keys and proceed to the parking area. There, straight out of your dreams, is an Indianapolis 500 race car. There must be some mistake! But the vehicle is in the designated parking spot and as the excitement builds, you discover the key fits. You rationalize, however, a car is a car. You successfully complete your first assignment, although you had difficulty starting the car, ground the gears during each shift, and stalled out several times. Of course, this specific scenario is absurd but we repeatedly emulate this situation in another application—our office data processing equipment.

Booming advancements in the automated processing capability have brought a significant change to the office environment. Almost every desk has some type of office automation equipment or, at least, some central office area available for automated processing work. Systems are significantly more capable than prior generations of equipment, and they are drastically more simple to use, maintain and operate. This had been achieved at a significantly decreasing cost. We recognize that office automation has increased office productivity.

However, is this efficient and effective? In today's environment, we find positive support toward office automation. It used to be a major bureaucratic challenge to acquire the simplest of office automation equipment. Many of us can remember it took almost 18 months to acquire a programmable, desk-top, electronic calculator of modest capability and cost. Nowadays, if an office doesn't have a computer on each desk, it is a simple matter to put in a request from the local catalog list for the standard computing equipment.

Normally, support for these systems is neglected, if not completely overlooked. Generally, however, support for automated systems appears to be very good. Normally, a "packaged" procurement provides the systems operations, product support, training, maintenance and a "help desk" to use this equipment effectively.

Also, we must not forget accompanying software requirements. There are more word processing packages that can be cited here, as well as many graphics and data base managers. It is not necessary to elaborate on the peripherals other than to acknowledge that we must have printers, plotters, modems, disc drives, controllers, etc., to complete an automated processing equipment suite. Justifications for these purchases are easily validated by using electronic mail, word processing, data base management, spread sheet, and the all-important graphics capability.

Normally, support for these systems is neglected, if not completely overlooked. Generally, however, support for automated systems appears to be very good. Normally, a "packaged" procurement provides the systems operations, product support, training, maintenance and a "help desk" to use this equipment effectively.

Now, after placing all this together, you have all the equipment and support necessary to manage and operate a modern automated system. Now what? You are probably surprised to hear that little has been done to formally bring the actual end-user into this planning. There has been no formal survey of what is required or desired from these systems. There has been no educational process to inform users of what actually is available, or of what can be obtained. Training has been and is extremely diverse. Many operators are self-taught.

The aforementioned packaged procurements have been productive. Experience shows that classes offered by the "package" method are difficult to obtain due to limited class size and/or the impossibilty of scheduling into the individual's schedule. Another criticism is that classes are usually structured to the lowest common literacy of the expected class student. Another method of training, and arguably the most effective, is a demonstration by a more experienced operator of basic principles of particular programs and the spontaneous assistance provided when a problem or question is apparent. This situation is obtained solely from my personal experience. No formal survey or expanded research was performed to validate or quantify this situation. However, these experiences reflect situations at five different locations within the Department of Defense (primarily Air Force) and have been generally confirmed through informal surveys with personnel in similar work environments in other parts of the federal government and civilian industry.

No claim is made about being an expert on modern computer systems, their capabilities, or training; however, I have noticed several areas that appear to offer obvious opportunities where efficiency and effectiveness can be improved. These areas will be explained in the following paragraphs: improved eduction of basic office automation equipment, increased training, and a novel approach for training of computer operators.

The first portion of this recommendation is a basic overview of modern office automation. It can be surmised that only a few individuals can claim to be totally familiar and articulate with all currently available office automation products. It is true that most exprienced operators would not need a basic introduction into fundamentals of computer principles; nonetheless, they could benefit from a discussion of the latest advances in hardware and software products. Further, there is the group that could benefit from a fundamental introduction to computer principles. The critical point of this education process would be to identify clearly the "how" and "what" when each specific operator uses office automated equipment. It is doubtful that every person in the office needs an individual copy of every word-processing package in the catalog. From practical experience, it seems that one, or at most two, software packages would be effective. I know several examples where an operator had created an original paper using one software package that had to be completely revised because the subsequent operator was not literate in that particular program. Also, does every computer need to have a dedicated printer and modem specifically identified for that operator? This is a "Catch-22" situation in that it is far easier and more convenient to acquire a "total system" at one station than it is to network numerous microcomputers into common input and output devices. A final observation is the amount of computational capability actually used. Experts estimate less than 5 percent of a microcomputer's actual computational capability is exploited. Does everyone require a fully equipped microcomputer station? Or, can we use instead a terminal to a mainframe, a network of micros, or even an electronic typewriter with memory or a dedicated word processor? This is a crucial area

It can be surmised that only a few individuals can claim to be totally familiar and articulate with all currently available office automation products.

where more "up-front" analysis and planning can contribute to more effective and efficient use of computer resources.

A second area where significant improvement is projected is in the training aspects. Training offered through the total package is commendable. The majority of these programs offer some variation of a two-phased approach: one being a formal classroom instruction format and the other being the all-important "help-desk."

The formal instruction usually offers a qualified instructor, structured lesson plan, and dedicated workstations solely for the purpose of training. Handouts/manuals are usually at a minimum; mostly reproduced "helpful hints" containing common problems encountered by the beginning student. Advancements in computer assisted training also must be recognized. Here, the student is instructed how to log onto the computer and to access lesson plans, then is left to progress at an individual pace during the training program. There are many negative aspects in this approach. Formal instruction is productive for the true beginners or in situations where class members have the same basic level of competence; situations not common in today's environment. Classes are usually small and at least relative to the number

desiring training; some require a degree of expense to maintain and operate. Quotas usually are established that often require commitments well in advance of scheduled training. Another major factor is making time available in a manager's schedule to attend training sessions. The biggest problem observed is the varying degrees of literacy of students. This requires instruction to be directed at the lowest levels and creates a major waste for the more literate. Also, the number of excellent-to-good computer assisted training programs are in the definite minority.

The other approach in the procured training packages is the "help desk." This refers to a unit which is on call, usually only during work hours in response to almost any type of computer problem. This can range from moving/installing hardware and peripherals, installing configurations, troubleshooting hardware problems, to assisting in software operations. The "help desk" personnel can be productive in working with a person who tried to gain experience and knowledge in a specific program, but did not fully master the program and had serious difficulties.

I recently exploited this service in an efficient and effective manner, which leads to recommendation of a third consideration. This originated when it was suggested the office use a previously unused feature on one of the integrated software packages. This contained its own training package which was quickly found to be ineffective. After practicing with this new feature and conferring with others more capable, operators were able to be modestly capable of using this new program. It had been estimated the office was exploiting at most 10 percent of its features, and was soon experiencing major problems. The friendly "help desk" was called and requested to provide a ½ hour session to "correct" problems. In effect, this resulted in a private training lesson totally dedicated to exact requirements and level of expertise of the office. As a result, it is estimated the office is now exploiting this system to at least a 50 percent level. A more significant accomplishment is introduction of at least a half-dozen associates beginning to use this feature.

Experts estimate less than 5 percent of a microcomputer's actual computational capability is exploited.

This experience caused me to investigate a new format for offering training programs. The experience, however, does not suggest changing the basic level of computer introductory courses. For the intermediate to advanced programs, it is recommended that a pilot project be offered. This pilot project would consist of training now offered to the most skilled individual in a section or work area. This individual would be expected to be generally computer literate with an understanding of concepts for the particular program to be learned. It would not be necessary for the same individual to be the student for all the educational programs. This training would be offered on an individual basis, without formal text or lesson plan, and would advance at the individual's capability. The individual selected for the pilot project would be expected to know the precise computing and processing requirements for the section or work area and could tailor the training to that goal. After receiving personalized training, the student would be called upon to train associates in the work area. This recognizes that a highly skilled computer operator would be expected to devote time to training co-workers. However, this would be more efficient and effective when one considers that the training would be specifically tailored to the desired application and would also be less than, or equal to, the amount of time currently diverted to responding to spontaneous problems or questions.

I began by describing an absurd scenario of using a race car for a local transportation requirement. An analogy was made for our use of computer products. Suggested improvements were made in basic education, increased training, and a pilot program. These steps could improve our effectiveness and efficiency in using computer systems.

However, I can still dream and hear those famous words: "Gentlemen, start your engines!"

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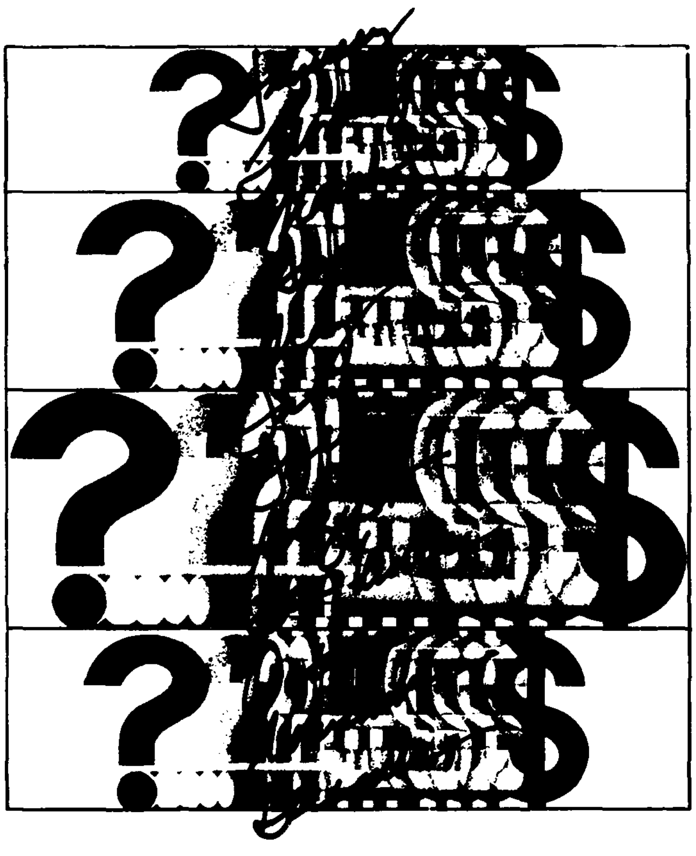
DISCOUNTING IN THE PUBLIC SECTOR, REVISITED

Thomas E. Anger



The Office of Management and Budget Circular A-94 prescribes the use of discounted costs in cost-benefit comparisons of alternative government projects. In my experience, the OMB prescription is honored most often in the breach—whether out of ignorance, indifference, or principled opposition I cannot say. But I will say that those who oppose the use of discounted costs on principle have a strong leg to stand on.

The proponents of cost discounting—and I must use such an awkward term because it is the rightness of cost discounting that is at issue here, not discounting per se—have their hearts in the right place. Other things being the same, it is better to defer a cost than to incur it because, in the interim, you can put the resources to work doing something else that's productive. Cost discounting, its proponents say, merely helps a government entity choose from among alternative programs those that will minimize the net cost—to "society" or "taxpayers" if not to the government entity—of accomplishing a particular job.

The way in which cost discounting helps government officials in their altruistic quest to lighten the burden on the backs of citizen-taxpayers is usually shown by a simple example, viz:

—Options A and B can do the same job at the same time;

—Options A and B both cost $100, but the cost of option A must be incurred in year 1, whereas the cost of option B doesn't come until year 2; and

—Because society or taxpayers or the government can use the $100 for something productive in year 1 (something that might yield a return that can help defray the cost of buying option B in year 2), it's obvious that option B should be chosen: It delivers the same goods as option A, but its net cost is lower.

Having demonstrated the irrefutable proposition that the timing of expenditures is important, the proponents of cost discounting move in for the kill, viz:

—An appropriate discount rate, applied to the costs of A and B, yields the same result. And a discount rate is easier to use in more complex cases, that is, where the cost "streams" associated with A and B in fact flow unequally and unevenly across several years.

When they discount the future benefits they try to take into account such factors as risk and uncertainty (e.g., the risk that the future benefits will not be realized because

something may go wrong, the possibility that inflation will reduce the future benefits that a dollar can buy, and the need for liquidity in the event of emergency expenditures or better opportunities). Their discounting of future benefits also incorporates their time preference, that is, the rate of return that will equate a future benefit to a benefit in the present (risk and uncertainty being held constant).

For the sake of simplicity, I will hold risk and uncertainty constant through the rest of this paper because they are merely complicating factors. The essential issue for government decision-makers and the public they serve is time preference—the rate of exchange between present and future benefits.

One possible measure of a private individual's time preference is willingness to save money at the rates paid by such "riskless" and "liquid" instruments as insured, interest-bearing, checking accounts. Willingness, at the margin, to entrust a dollar to a bank for a return of 5 percent a year reveals a preference for $1.05 worth of the things money can buy a year from now over the things $1.00 can buy today.

Your time preference may be something else entirely, and if it is you will find other ways to invest your money—taking due account of risk and uncertainty, of course. Some of you may even make negative investments, that is, you will go heavily into debt at rates of interest exceeding 10 percent for the sake of present enjoyment (e.g., a new car that provides more than transportation to and from work).

Once we roam beyond the realm of the individual, however, the operational meaning of a time-preference discount rate becomes more vague. An investment decision by the "head of household" is more likely to reflect his or her time preference than that of the abstract "household." An investment decision by a business manager may reflect his or her time preference and perhaps the consensus of a small group (e.g, the finance committee of the board of directors), but it is unlikely to reflect the time preferences of many shareholders except by coincidence.

Of course, in the "long run" a corporate investment decision will coincide with the preferences of shareholders, thanks to the magic of the market. But we know what Keynes said about the long run.

Discounting in the Public Sector: The Social Rate of Discount

From the preceding discussion, it should be obvious that no government decision-maker or decision-making body can legitimately discount on behalf of such abstract entities as society. Some analysts will nevertheless urge decision-makers to presumptive behavior. Decision-makers (if not analysts) must be disabused of the theoretical validity of such behavior.

Let us begin with the case for the use of a social rate of discount, as made by Professor Baumol:

> The appropriate rate of discount for public projects is one which measures the social opportunity cost. The decision to devote resources to investment in a public project means, given the overall level of employment in the economy, that these resources will become unavailable for use by the private sector. And this transfer should be undertaken whenever a potential project available to the government offers social benefits greater than the loss sustained by removing these resources from the private sector. The social rate of discount, then, must be chosen in such a way that it leads to a positive number for the evaluated net benefits of a public project if and only if its gross benefits exceed its opportunity costs in the private sector.[1]

This argument has two implications. First, a public project should be undertaken if its discounted benefits outweigh its discounted costs. Second, the choice among alternative public projects that can deliver the same benefits to the private sector should be made by discounting their costs to see which adds the largest net benefits to the private sector. If the benefits cannot be measured in terms of dollars, that project which has the lowest discounted costs should be chosen, for it will at least minimize the disbenefits that the undertaking imposes on the private sector.

It is true that government decision-makers (the Congress, in particular) may withdraw resources from private use for government projects. But decision-makers cannot thereby make society better off, because society is composed of individuals with unique tastes (including *dis*tastes for government projects of any type) and preferences (including time preferences).

Consider the simple, and unlikely, case in which *all* members of society (or taxpayers, if you prefer) would part willingly with their money to support a particular type of government activity. Even then, there is no rate at which government decision-makers can discount costs for the purpose of identifying the particular program that will minimize the net social cost of the activity. If the decision-maker chooses a rate of 10 percent, he penalizes individuals whose private discount rates are above 10 percent. Examples follow.

—Either project C or project D can provide a given service (same benefits delivered at the same time).

—Project C will cost each taxpayer $100 in year 1; project D will cost each taxpayer $110.01 in year 2.

—By discounting at 10 percent, the decision-maker favors project C because its discounted cost is slightly less than that of project D.

—Each taxpayer therefore gives up $100 in year 1 instead of $100.01 in year 2.

—Taxpayers whose discount rates are greater than 10 percent would rather have $100 in year 1 than $110.01 in year 2. If, for example, my discount rate is 15 percent, the present value to me of $110.01 is $95.66, $4.34 less than the $100 I'm being forced to give up.

Professor Baumol admits that "no optimal [social discount] rate exists.[2] My analysis suggests a stronger con-

clusion: The use of discounted costs to justify any type of government activity or to choose a particular means of carrying out a government activity does *not* benefit society. The concept of a social rate of discount is meaningless. Any decision about government activity, regardless of the justification for the decision, results in a purely arbitrary reallocation of income and wealth among individuals and between individuals and government.

Internal Rates of Return

"Aha," says the inveterate discounter, "you're right about that aspect of discounting, but you forgot that a decision-maker can use his internal rate of return to discount for another reason, namely, to maximize the services he can deliver to the public for a given cost or to minimize the cost of providing a particular level or primary service."

For reasons that will become clear, in addressing the internal-rate-of-return argument it is important to distinguish between the primary services that presumably benefit the public (e.g., defense) and the secondary services (e.g., maintenance) that enable the delivery of primary services. To take another example:

—Projects E and F can do the same job, that is, deliver 100 units of primary service in year 3.

—Project E would cost $100 in year 1; project F would cost $109.99 in year 2.

—The decision-maker has a long list of projects he would like to undertake when funds are available. One of these is a maintenance project (call it project G) that would cost $100 in year 1 and which would reduce repair costs by $10 in year 2, a 10-percent rate of return.

—Therefore, the decision-maker should select project F and invest $100 in project G in year 1. When year 2 rolls around, he'll have to spend $10 less than usual on repair costs, thus reducing the net cost of project F to $99.99, as compared to the $100 he'd have to spend on project E.

Sounds great. Unfortunately, it's an incomplete analysis of the decision-maker's task.

The availability of cost-reduction measures in the form of secondary services is the cost discounter's *deus ex machina*. Or perhaps I should call it the cost discounter's Pandora's box. Having opened the lid to unleash project G as an alternative way of spending $100 in year 1, it would be arbitrary to deny the existence of an alternative way of spending $99.99 in year 2, through project H, which would deliver 50 units of primary service in year 3.

Now the decision-maker is faced with these choices:

—Combination I, projects E and H

—Combination II, projects F and G.

The combinations cost the same amount in years 1 and 2.[3] Combination I yields a higher level of primary service in year 3 (150 units) than combination II (100 units). But combination II potentially delivers higher levels of primary services in later years because of the downstream effects of the maintenance project (project G). Patently, the decision-maker cannot choose between these combinations by applying a discount rate to their costs. Yet, had the decision-maker applied a cost-discount rate (*any* cost-discount rate) to the choice between projects D and E, he would in fact have chosen one of the two combinations by default. Slavery to a cost-discount rate can well lead a decision-maker to a choice he would regret, were he given more facts.

Any rate that would lead to the "right" choice would have to reflect foreknowledge of the choice. In other words, the analyst can pick the proper rate only after he knows which option is consistent with the decision-maker's view of how he wants to shape his stream of primary services. The decision-maker's view is likely to vary with the particular type of service under consideration. In defense, for instance, it might be better to increase strategic defensive forces (as against conventional forces) in the near-term, to foster negotiations that might lead to arms reductions in the long-term.

In summary, *cost* discounting deals in the wrong coin—returns on investments in secondary services. The comparison of options on the basis of discounted costs obscures the real choice that a decision-maker must make—the choice between alternative streams of primary services.

How to Do It Right

There's only one right way to help the decision-maker confront his real choices: Give the decision-maker the facts, don't hide them under a bushel of discounted costs. When required to choose between alternative ways to perform a particular service, the decision-maker needs to know what other services he would give up in choosing each of the alternatives. He must make up his own mind about the flow of primary services he should provide for any given stream of projected funding.[4]

Continuing with the example of the preceding section, the analyst who wants to illuminate matters rather than cloud them would show the decision-maker Table 1.

Elegant? No. Such an approach doesn't wrap everything into a few numbers and let the decision-maker play "multiple choice." The proper test of analysis, however, is not its elegance or whether it lends comfort to the decision-maker. The proper test is whether an analysis furthers the decision-maker's understanding of his options and, therefore, his ability to choose the stream of primary services that seems appropriate, given his understanding of his duty.

Author's Note: *I owe an intellectual debt to many; five creditors deserve special mention. In 1966, when he was at the Center for Naval Analyses, Dr. Vartkes Broussalian wrote two papers on discounting, "The Evaluation of Non-Marketable Investments" and "Discounting and Risk in Military Investment Decisions." I revisited those papers in writing this one; their influence will be evident to the initiated. Dr. Broussalian gave helpful comments on an early draft of this paper, as did Dr. Rolf Clark of George Washington University. (Now on the faculty of the Defense Systems Management College.)*

TABLE 1. ILLUMINATING MATTERS

Combination	Year 1	Year 2	Year 3	. . .	Year N
I (Projects E and H)					
Costs	$100	$99.99	. . .		
Benefits	-	-	150	. . .	
II (Projects F and G)					
Costs	$100	$99.99	. . .		
Benefits	-	-	100	. . .	

It was Dr. Clark's article ("Should Defense Managers Discount Future Costs?") in the March 1978 issue of Defense Management Journal that sparked the 2-year-long debate in the pages of that journal which, in turn, led me to begin writing this paper several years ago. Many of my colleagues at the Center for Naval Analyses read and commented on various drafts of this paper. Dr. William F. Morgan, Jr., gave especially helpful advice on the topic of the final section—how to compare options for government decision-makers. Dr. Fredrick D. Thompson's criticisms of a late draft helped me tie up some logical loose ends. Professor Robert M. Solow of the Massachusetts Institute of Technology responded vigorously and wittily to my request for his views on a late draft. To the named and unnamed whose thoughts have aided me, even when we disagreed, sincere thanks. Whatever flaws you may find in this paper are, of course, all mine—if they are not in the reader's imagination.

Endnotes

1. William J. Baumol, "On the Social Rate of Discount," *American Economic Review*, September 1968, pp. 789-90).

2. Baumol, *op. cit.*, p. 798.

3. The military departments have faced such choices, explicitly, since 1970 in allocating their multiyear spending targets (called "fiscal guidance"). Fiscal guidance has been used (more or less successfully) to promote the development of coherent, multiyear defense programs. Whether or not a decision-maker receives fiscal guidance, the fact remains that the decision-maker always has more than one way to spend a given amount of money in a given year. Consider the budget the President submits annually (or is it biennially?) to the Congress. If the President can ask the Congress for $100 in year 1 to buy E, he can ask the Congress for $100 in year 1 to buy H, instead; and so on, for year 2, year 3, etc. Of course, it makes sense to ask for things that the Congress is likely to approve, but that's another issue. As long as there are plenty of potential projects (and when haven't there been?) the decision-maker's real choice is between projects that could be funded with the same amount of money in the same year.

4. The decision-maker's task would be easier if he could plan on a fixed stream of primary services, whose costs must be minimized in every year. But that is not a realistic option, given the layers of executive and legislative bureaucracy that willy-nilly review and revise their concepts of services, the amounts that are deemed desirable, and the budgets that are required to turn plans into realities.

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DOLKAS/GOVIER

(Continued from page 25)

Endnotes

1. *Programming Productivity*, McGraw-Hill, 1986, T. Capers Jones.

2. "Looking for the Right Pond," *DATAMATION*, August 1984, F. Druding.

3. *A Software Development Environment for Improving Productivity*, *I.E.E.E.*, Computer, 1984, B. W. Boehm, M. H. Penedo, Don Stuckle, and R. D. Williams, TRW; A. B. Pyster, Digital Sound.

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6. *Software Engineering Economics*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981, B. W. Boehm.

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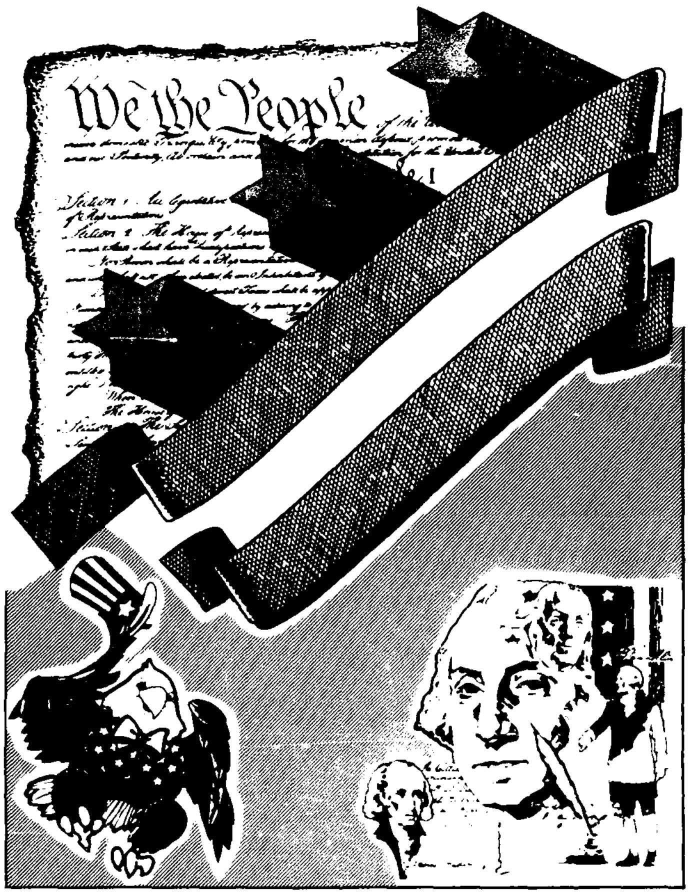
DOD ACTIONS TO INCREASE ACQUISITION PRODUCTIVITY

(Last of a Series)

Dr. Andrew P. Mosier



SSGT Lowell Gilstrap, USAF

The Preamble to the Constitution states our highest national objectives. They include "provide for the common defense, promote the general welfare, and secure the blessings of liberty to ourselves and our posterity." These objectives are interdependent. Achieving each depends on public money and, where our posterity are concerned, on how the money is raised—by taxes or by borrowing. Today, "we the people" face seemingly unsurmountable problems in achieving these objectives to our mutual satisfaction. Public funds from taxes are constrained, the public debt is huge, and reducing the deficit has high priority.

President George Bush, in his inaugural address, spoke of "new engagements" instead of relying on public money alone to end our problems. For promoting the general welfare of all the people, he spoke of "a new engagement in the lives of others, a new activism, hands-on, involved...that gets the job done." He called for a new engagement between the Executive Branch and the Congress to "ensure that America stands before the world united: strong, at peace and fiscally sound."

Given our present fiscal bind and many difficult domestic and international problems to be solved, we need a new engagement in most activities supporting these national objectives—a new activism by the people involved. New activism at all levels in each activity would assure more efficient use of public funds in the activity, and more productivity and greater achievement of objectives by the activity.

We urgently need a new engagement to ensure adequate defense. One of the crucial challenges of the Bush Administration, given its financial, domestic and international problems, is assuring adequate continued defense of our liberty in a changing upredictable world, and so preserve our freedom to "promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity."

Acquiring defense systems is a key activity in assuring adequate defense. Given the deficit and inevitable reductions in future defense budgets, I believe the most promising and, perhaps, only means for assuring adequate defense is a new engagement to increase substantially the productivity of the Defense Systems Acquisition Management (DSAM)[1] process for acquiring and modernizing defense systems. To be effective—more than a slogan—this new engagement should actively involve DSAM professionals[2] at every level of acquisition activity throughout the acquisition community.

To succeed with this new activism we must tap the full potential of all DSAM professionals and avoid too early fixation on emerging computer and information technologies. Too much reliance on technology over human ingenuity in

past attempts to automate information access and decision-making in defense acquisition has often caused great waste.

As I will show, we can release this human ingenuity by developing the DSAM taxonomy, mainly with help by DSAM professionals. In turn, the taxonomy will help these professionals organize, assemble, expand, and maintain acquisition management knowledge for prompt access when needed by any DSAM professional. In addition, the taxonomy will support effective utilization of emerging technologies to store and retrieve timely "right" information when a professional needs it for tasks at hand. Symbiotic interaction of "knowing" professionals with "right" information, aided by advanced technology, will increase productivity substantially in defense acquisition jobs and tasks.

Background

The overall DSAM process has been the focus of this series. In the first article,[3] we examined the inherent consequences of the large scope, complexity and intense interactiveness of dynamic processes used to acquire defense systems. I developed an analytical framework of elements of acquisition organization productivity, as a tool for identifying new opportunities to overcome or cope better with these consequences and increase productivity in acquisition management.

I used elements of the framework to organize research on past efforts to improve management of defense acquisitions, and identified opportunities in three areas of the DSAM process. I found one approach for improving acquisition management that has been notably successful. It should be emulated to continue improving the DSAM process. In two critical areas of the DSAM process, however, past efforts have not been sufficient. These insufficiencies must be remedied, or the elements of both areas coped with better, to expedite DSAM process improvements.

Summarizing these and other findings in the second article,[4] I concluded that focusing research and action on these three DSAM areas could expedite improvements in the acquisition process which would increase productivity of every DSAM professional. Then, these more productive professionals operating with improved acquisition processes would increase productivity of the DSAM process substantially—improve quality, reduce costs, compress schedules, and hasten achievement of intended performance for new or modernized systems.

> The Congress and the new Administration should examine carefully any actions sparked by the wide publicity of recent allegations and indictments for unethical and unlawful individual conduct....

In the third article,[5] I proposed a general DOD initiative for each of the three DSAM areas or fronts. Each initiative would serve as a long-term strategy on its front, focusing planning and direction of specific actions to increase productivity in management of defense acquisition. In brief, the three interdependent initiatives are:

—Continue increasing integration of major DSAM processes

—Manage constructive change of defense acquisition environments

—Provide DSAM knowledge system aids that help DSAM professionals.

Focusing on the third initiative, I presented new concepts needed to understand it, and to plan and direct actions to provide DSAM knowledge system aids, enabling real progress on all three fronts.

In this fourth article, I propose urgent first actions supporting the three initiatives. Before discussing these actions, however, we should understand the necessity to avoid stampeding into hasty action that could decrease productivity in defense systems acquisitions. Specifically, the Congress and the new Administration should examine carefully any actions sparked by the wide publicity of recent allegations and indictments for unethical and unlawful individual conduct among government personnel, private consultants, and contractor managers.

Productive acquisition management requires government-contractor teamwork. Effective teamwork in all defense acquisitions depends on honest ethical individuals. Design of efficient acquisition processes is based on the implicit assumption that people working in acquisition are honest and ethical—because the vast majority are. For cases where this assumption is violated, a positive remedy is severe punishment of unethical or unlawful behavior, and prompt expulsion and certain punishment of any individual who acts unethically or unlawfully.

Additional inflexible, time-wasting "thou shall not" laws and directives to cope with the unethical minority are not the remedy. These will only reduce efficiency of the DSAM process and decrease productivity of the honest majority—further increasing and delaying deliveries.

Knowledge Systems Initiative

The three DOD initiatives proposed and new concepts and ideas presented previously, help prepare for a new management—a new activism by DSAM professionals. This will increase productivity in acquisition substantially by increasing productivity of all professionals; directly, through the third initiative, and indirectly, through the first two.

We focus first on the third initiative, provide DSAM knowledge system aids that help DSAM professionals. These aids will provide acquisition professionals with more timely and selective access to the body of DSAM knowledge and information and, thus, increase productivity in their respective acquisition jobs and daily tasks. In addition, some professionals need this timely access to design actions that directly support the other two general initiatives (increase integration of DSAM processes and manage constructive change of DSAM environments), which will increase productivity of DSAM processes that all professionals use.

Four actions are required to start evolutionary development of DSAM knowledge system aids:

—Develop a prototype DSAM taxonomy, which can be tested, improved, and expanded through field testing and operational use

—Simultaneously use taxonomy terms (taxa) to assemble and integrate a complementary DSAM glossary of authenticated definitions and acronyms so that the integrated DSAM taxonomy-glossary can be used to structure unambiguously and inventory the body of DSAM knowledge and information

—Begin to use the integrated DSAM taxonomy-glossary in many ways vital to increasing productivity in acquisition management

—Encourage evolutionary development of defense acquisition corporate memory data banks[6] throughout the acquisition community, using the DSAM taxonomy-glossary to index and interconnect the data banks so they function together as responsive DSAM knowledge systems (providing timely selective access to relevant knowledge and "right" information—relevant, accurate, current, uncluttered yet sufficiently complete.)

Taxonomy of DSAM Knowledge

Let's look first at main considerations in developing a useful DSAM taxonomy. Webster says a taxonomy is "The systematic distinguishing, ordering, and naming of type groups within a field."[7] In general, the purpose of a taxonomy is to provide a delimiting classification structure for organizing and inventorying different kinds of entities of a discipline's or of a field's body of knowledge,[8] and to provide names of type groups entities, known as taxa. These names can be used as subject indexes in information storage, search and retrieval. However, a taxonomy of the body of DSAM knowledge and information will be much more than a subject index for data banks in DSAM knowledge systems.

> The taxonomy of a field's body of knowledge is the bootstrap by which professionals in a new field inventory their professional knowledge, identify voids to be filled....

A comprehensive DSAM taxonomy, with complementary DSAM glossary, is the key for unlocking crucial productivity increases in the field of defense acquisition management. A taxonomy has more uses than organizing and structuring a field's professional knowledge. It supports the field in educating its professionals, classifying its professional operations and research, and communicating professionally with greater clarity and understanding. Moreover, a new field cannot be effectually developed, organized or recognized as a true profession until it has some kind of taxonomy to organize and inventory its professional knowledge.

The taxonomy of a field's body of knowledge is the bootstrap by which professionals in a new field inventory their professional knowledge, identify voids to be filled, organize research to fill them, achieve professionalism, plan integrated operations, increase productivity, and advance their field's contribution to society. Entrants to a new field cannot be fully educated to communicate and operate effectively in the field, until the field's leaders work together to develop taxonomies, consolidate and use them to inventory the field's body of knowledge, and develop sound professional education curriculums.

The professions of science, law and medicine have long distinguished, ordered and named taxa within their respective disciplines and fields, and developed and maintained taxonomies of their respective bodies of knowledge. Defense acquisition professionals have no consolidated taxonomy of the body of defense acquisition management knowledge. There is no comprehensive DSAM taxonomy that professionals throughout the defense acquisition community can use (and urgently need) to attain more productive management of defense acquisition.

In making a decision regarding development of a DSAM taxonomy, several questions must be answered. The scope of the taxonomy should include the whole body of DSAM knowledge and information needed to manage defense acquisition productively. But, what is that scope? How should the DSAM taxonomy be structured? How can we best ensure the taxonomy is not ambiguous? How can we assure the taxonomy is developed and maintained by leading professionals in the field? How can we assure it will be useful to professionals working at all levels in the defense acquisition community? I will address each question.

Scope

First, what should be the scope of the DSAM taxonomy; i.e., scope of the needed body of DSAM knowledge included within the boundaries of defense acquisition? The complete scope must be determined by professionals in defense acquisition based on

their knowledge and information needs, but here is an illustrative listing that my research suggests the scope should include.

—**Integrated Hierarchy of Defense Acquisition Strategies and Related Policies.** This should include a DOD Acquisition Strategy at the apex of a hierarchy of supporting strategies including system acquisition strategies of all program management offices (PMOs) and organization strategies of all other acquisition management and support organizations. (See DOD Acquisition Strategy below under Other DOD Actions.)

—**System Acquisition Cycle Phases and Decision Points.** Much essential specific DSAM knowledge and information, from needs determination through obsolete system disposal, is system life-cycle phase sensitive.

—**Other Defense Acquisition Cycle Phases.** These are phases that precede, support or follow system life-cycle phases, beginning with threat evaluation and including DSAM problem identification, research, and information dissemination and feedback.

—**Other Defense Management Functions that Impact Acquisition.** This includes such functions as comptroller, personnel, construction, security, fraud investigation.

—**Management Functions and Activities Performed in Each Phase.** This includes business, technical management and training functions, recognizing how they differ in each activity and how they change with acquisition phases.

—**Types of Defense Systems/Programs.** This includes aircraft, ships, tanks, missiles, guns, and communications and electronics (mobile and fixed). Type group (taxon) naming and distinguishing must recognize how system type influences a system's acquisition phases, procurement mode and program management functions.

—**Directive/Non-directive DSAM Knowlege/Information.** Directive information (regulatory what-when and necessary constraints) and non-directive information (optional alternatives, how-to and lessons-learned) must be differentiated to allow future information-based centers of management excellence freedom to decide the most productive means for accomplishing directed acquisition objectives. To avoid confusion, non-directive information should no longer be included in policy and directive documents, except to reference where optional alternatives or how-to information may be found if needed.

—**Authorized DSAM Processes/Procedures/Plans.** Examples are project plan, acquisition strategy, and ILS plan, which require DSAM information and run through various parts of a systems life cycle.

—**Identified Subsets of DSAM Knowledge and Information.** This includes data on organizations involved in defense acquisition, and reference sources of DSAM knowledge and expertise for consultation.

—**Management Tools.** Planning, analytical, and statistical tools needed for productive management should be distinguished and named here.

—**Types of Defense Missions, Jobs, Tasks.** Different type groups (taxa) of acquisition missions, jobs and regular job-related tasks require different DSAM job-knowledge and different DSAM task-related information. Mission, job and job-task taxa, which require particular types of job- and task-knowledge, should be distinguished and named here. The 15 acquisition job functions identified in the December 1985, *Acquisition Enhancement (ACE) Program Report*, published by the DOD inter-Service/Agency group, are examples.[9]

—**Environments of Defense Acquisition.** The environment within which DSAM processes function, with which they interact, and that can seriously impact defense acquisition should be distinguished and named here. Environments arise from sources external to defense acquisition—DOD-wide policies, policies of other federal government departments and agencies (e.g., Energy, Commerce, Treasury, OMB, OFPP, NASA), executive orders, laws and treaties. Environment taxa can be used to identify potential areas for constructive change, and best means for coping better within environments that cannot be changed. Potential areas for change include the national planning and budgeting processes, authorization and appropriations processes, civilian and military personnel management processes, congressional oversight processes, military construction processes and other processes, policies, and constraints arising from external sources. A substantial part of the 1986 Packard Commission Report[10] discussed need for constructive changes in environments of defense acquisition, particularly in national planning and budgeting, and personnel management processes.

This list is meant to be illustrative. It is far from complete and contains overlaps that must be resolved. But, it indicates the scope of a DSAM Taxonomy that should be useful to professionals in the defense acquisition community and identifies some of the knowledge and information it must include.

Structure

In providing this preliminary indication of the scope of the DSAM Taxonomy, I have systematically distinguished, ordered and named some major taxa, thereby unavoidably introducing a structure. But, the structure of a body of knowledge is always initially arbitrary, and it may be structured in many ways. This brings us inevitably to the next question. How should the DSAM taxonomy be structured?

The best structure for a taxonomy is that which is most useful to professionals using it. These professionals must, therefore, be participants in development, testing and maintenance phases of the structure and scope of the DSAM taxonomy to ensure its usefulness.

My research indicates the basic design of the structure should be mainly hierarchical, but with some network aspects. I believe the taxa category, national military strategy, established within the framework of national objectives, should appear at the the taxonomy's apex. A main purpose of defense acquisition is to acquire and support defense forces and systems best supporting the national military strategy within resources allocated for national defense. One could argue the

apex taxa category should be national objectives, or equivalent level, since defense acquisition competes with other national security and domestic programs for national resources, and the defense budget is influenced by them.

The taxa category, DSAM (defense systems acquisition management), should appear on the second tier above most of the remaining categories of the DSAM taxonomy, since the main purpose of DSAM is to help acquire defense systems that best support the national military strategy within allocated resources. It is this purpose which differentiates DOD acquisition of advanced defense systems from DOD procurement of general supplies for operations and maintenance of all DOD elements. This is an important distinction in training and assigning procurement contracting officers (PCOs) for procuring state-of-the-art systems as opposed to contracting officers who administer contracts for off-the-shelf supplies. This distinction should be reflected through the taxonomy.

Under DSAM, the broad third-level tier of the taxonomy should include hierarchies of most of the taxonomy taxa listed above under scope. These third-level hierarchies should extend to lowest-level organizations involved in defense acquisition, through program/project management offices (PMOs) to all organizations significantly supporting management of system acquisitions.

Lateral from DSAM category in the second tier, but under an EODA (environment of defense acquisition) category, the taxonomy should include external hierarchies of other related knowledge and information that are used in, constrain or otherwise significantly impact management of defense system acquisitions. These are the environments of defense acquisition identified above under scope—environments within which DSAM processes function, with which they interact, over which the Under Secretary of Defense for Acquisition (USDA) has little direct control, but which can have a major influence on defense acquisition proceses.

Running throughout these hierarchies in the taxonomy, there should be linkages between related taxa; e.g., between a function and a tool used in the function, or between similarly named functions in different phases of the acquisition cycle or in different departments or agencies. These linkages change the taxonomy from sets of hierarchical frameworks into a taxinomical network. This network of related type groups will increase the usefulness of the taxonomy as a classification system and as an information retrieval aid.

Professionals will use the taxonomy first to inventory, assemble, organize, classify and store the body of DSAM knowledge and information; and then, as an index to locate relevant information for performing tasks at hand—in systems acquisition, defense acquisition education, acquisition management research, and dissemination of DSAM information.

Ambiguities

The usefulness of the taxonomy in inventorying and indexing the body of DSAM knowledge can, however, be severely limited by ambiguities in terms used in the taxonomy as taxa (type group names). During earlier 1976-78 efforts to develop a prototype taxonomy, and to use its terms to inventory, classify and index useful DSAM knowledge, and retrieve timely relevant DSAM information, we discovered a frequent source of critical misunderstandings in systems acquisition.

We found that many terms used as taxa in the 1977 prototype taxonomy were defined and interpreted differently by users with different functional or military service backgrounds. In designing the Defense Systems Management College Corporate Memory data base in 1980, I planned to remedy ambiguities in the taxonomy taxa by developing simultaneously a complementary glossary of DSAM terms, definitions, acronyms and synonyms that would define each term used as a taxon in the DSAM taxonomy.

In the first article of this series, I discussed serious Tower of Babel consequences of present DSAM language (terminology, jargon) not being truly common throughout the acquisition community. Too often this results in misunderstood communications. These are a large source of government and industry waste, causing unexpected reductions in defense acquisition productivity that are evident in many different forms including reworks, schedule delays, and increased costs.

I planned to help remedy underlying DSAM language deficiencies by expanding this initial taxonomy-related glossary into an unabridged DSAM dictionary data bank. Readily accessible by DSAM professionals everywhere, it would help make the language used in defense acquisition more truly common throughout the acquisition community.

My approach in 1980 was modeled after, and planned to build upon the *Compendium of Authenticated Systems and Logistics Terms, Definitions and Acronyms,*[11] published in 1981 by the Air Force Institute of Technology. Cancellation of DSMC Corporate Memory development precluded this common language initiative, but it is still a valid approach for developing an unambiguous DSAM taxonomy and for promoting a truly common DSAM language.

Role of DSAM Professionals

In addition to being unambiguous, the taxonomy must be useful to DSAM professionals working at all levels in the defense acquisition community. Assuring this presents problems. First, we must devise means to encourage leading professionals in the field of defense acquisition to help develop a useful prototype DSAM taxonomy. It must then be tested to get improvement feedback from professionals throughout the acquisition community—those responsible for defense acquisition policies, policy implementation, professional acquisition education, DSAM research and dissemination of DSAM information. The field of defense acquisition management is dynamic so, after the DSAM taxonomy is developed and tested, it will have to be maintained current and useful by continued feedback from these professionals.

The leading defense acquisition professionals must be actively involved. All groups of DSAM professionals must participate and be represented in developing, testing and maintaining an unambiguous DSAM taxonomy to assure its continued usefulness to all future groups of professionals working in defense acquisition.

Fortunately, this should be easier than in 1980, when leaders everywhere depended more on "completed staff work," rather than getting directly involved with the systems that provided information necessary for their management decisions. Using a terminal in 1980 to interact directly and immediately with information, like using a typewriter to type, was not then done by real managers. The increased sophistication of stored information and emergence of powerful personal computers have now made it not only acceptable, but necessary, for defense acquisition managers to get involved with development of information systems and data bases they rely on, and to interact more directly with the management data the data bases and systems provide.

Leading professionals in defense acquisition now have knowledge and motivation to be more actively involved in operational design of systems that collect, organize, and make available relevant information needed to perform acquisition management tasks more productively. These leaders, who had the responsibility and now have the capability, should support development and maintenance of the taxonomy and complementary glossary as an integrated DSAM taxonomy-glossary for unambiguously structuring and inventorying the body of DSAM knowledge.

Integrated DSAM Taxonomy-Glossary

We have long needed a truly common DSAM language to help reduce misunderstandings in acquisition communications, which cause waste in defense acquisitions. As we face reductions in future defense budgets, the need for a truly common language is urgent to help reduce waste, increase acquisition management productivity substantially, and assure adequate defense.

We have long needed a truly common DSAM language to help reduce misunderstandings in acquisition communications....

The first action toward a truly common DSAM language is assembling a DSAM glossary of authenticated definitions and acronyms of terms used as type group names (taxa) of the prototype DSAM taxonomy. This action will support two complementary objectives, both important to increased acquisition management productivity:

—Make the DSAM language truly common

—Develop an unambigous integrated DSAM taxonomy-glossary.

Achieving the first objective will enable communications with greater understanding among DSAM professionals throughout the acquisition community in:

—Different functional areas of systems acquisition—contracting, engineering development, manufacturing (each with its own jargon)

—Different military services (which the 1981 AFIT *Compendium* shows often have different authenticated definitions for the same DSAM term)

—Other government and industry segments involved in, or having a large impact upon, defense acquisitions (in different agencies and different industries, each with its own set of terminology).

Furthermore, expanding the glossary part of the DSAM taxonomy-glossary into an on-line (or CD-ROM disc) DSAM dictionary for all to reference, will strengthen the common language initiative and diminish the "Tower of Babel" syndrome. The resultant reduction in misunderstandings in defense acquisition communications—in legislation, policy-making, program execution and support—should reduce waste and boost productivity of professionals throughout the acquisition community, greatly increasing overall productivity in acquisition management.

Achieving the second objective, an unambiguous integrated DSAM taxonomy-glossary, is vital to increased productivity in acquisition management for three important reasons.

First, it is required to begin developing a common DSAM language:

—By providing essential core terms, with authenticated definitions, acronyms and synonyms, to foster a truly common language

—Providing hierarchical and other linkage relationships among these terms, enabling cross-reference and understanding or related ideas, concepts and knowledge.

Second, the DSAM taxonomy-glossary will have many other productive uses resulting from the fact that it is a comprehensive inventory of the body of DSAM knowledge and information. It can be used to:

—Organize reviews of defense acquisiton management curricula and courses to identify critical voids and, while considering given time constraints, evaluate the comprehensiveness and balance of curriculums and courses.

—Identify opportunities for integrating major defense acquisition processes for increased productivity, and to guide and evaluate progress in their integration (e.g., integration of the DSAM research and the DSAM information-dissemination processes, as discussed under Research and Information integration below in Other DOD Actions).

—Support defense acquisition management as a true profession—more than

a program/project management career ladder for government civilian and military personnel.

—Provide the nucleus for an unabridged DSAM dictionary.

—Serve as principal tool for continuing update and maintenance of a common DSAM language.

Third, a DSAM taxonomy-glossary is a prerequisite for developing other aids to help DSAM professionals increase productivity. It is required to develop a comprehensive *defense acquisition corporate memory*, comprising data banks located throughout the acquisition community, and to interconnect the data banks via a common DSAM language. The DSAM taxonomy-glossary's common structure of core names and definitions is required to organize, identify and connect all components of the acquisition corporate memory for timely access to relevant knowledge and information.

More specifically, a DSAM taxonomy-glossary would serve all managers of distributed data bases in the defense acquisition corporate memory as the common standard for:

—Identifying and evaluating useful items of DSAM knowledge and information.

—Organizing, classifying and indexing these items for storage in useful knowledge systems, data bases and repositories.

—Establishing communication links among distributed knowledge systems, data bases and repositories comprising the corporate memory.

—Retrieving timely relevant knowledge and information from the distributed corporate memory when needed to help professionals perform effectively each task at hand.

DSAM Knowledge Systems

In the dynamic field of defense acquisition, many uncontrollable factors cause frequent turnovers and significant changes in jobs of DSAM professionals. These turnovers and changes create a continuing need for relevant DSAM job knowledge and task information. Yet, my research of past acquisition management indicates one of the most pervasive insufficiencies inhibiting acquisition management productivity has been lack of good acquisition corporate memory. A useful corporate memory requires systems that can provide timely access to needed job- and task-relevant DSAM knowledge and information stored in the memory.

Need for a useful acquisition corporate memory has been greatest among large numbers of new incumbents in acquisition—the effect of turnovers resulting from changes in administrations, reorganizations, tour rotations, and promotions and retirements, and from system acquisition programs entering a new phase. This insufficiency resulted mainly from lack of capabilities to inventory, structure, organize, index and store useful items of the body of DSAM knowledge in a corporate memory and, thus, the lack of a corporate memory to search selectively and retrieve timely relevant job knowledge and "right" information.

Now, an integrated DSAM *taxonomy-glossary can provide* these capabilities in DSAM knowledge systems. It can be used in every acquisition organization, first in developing knowledge system data banks of useful items of DSAM knowledge and information and, then, as an aid to its professionals for obtaining needed DSAM knowledge and retrieving timely relevant information for performing tasks at hand.

Moreover, the taxonomy-glossary can serve to help interconnect manually-operated and computer-aided DSAM data banks of all acquisition organizations and, thus, interconnect the whole distributed defense acquisition corporate memory. The common DSAM terms of the taxonomy can be used to help interconnect on-line data bases electronically. The integrated taxonomy-glossary can help managers of information centers and physical respositories throughout the acquisition community communicate unambiguously, supporting comprehensive, yet selective, searches and providing timely and relevant DSAM documents and information.

The DSAM taxonomy-glossary can provide a common DSAM subject authority for uniform subject classification and indexing of inputs to all DSAM data banks; and support a truly common DSAM language to enable clear unambiguous research and retrieval. Thus, effective communications among distributed DSAM data banks of the defense acqquisition management corporate memory, and between them and professionals, heretofore not possible, is now feasible.

The taxonomy-glossary will enable maintenance of the following different categories of corporate memory data banks. These examples indicate some of the kinds of knowledge, information and communication aids for acquisition professionals which could be developed as elements of DSAM knowledge systems that can evolve into a comprehensive defense acquisition corporate memory.

—**DSAM Documents.** These include knowledge and information that are documented in printed documents, and in full text or bibliographic data files in magnetic or optical media (e.g., magnetic disk, CD-ROM disc, optical disc juke boxes). Secondary sources, where full text documents can be promptly obtained, would be listed in all bibliographic data records to expedite receipt of the full text by DSAM professional.

—**DSAM Expertise.** This includes knowledge or information that is accessible in expert systems, and sources of organizational and personal DSAM expertise available for consultation; e.g., special information centers, principal investigators of ongoing research projects.

—**Ongoing DSAM Research Projects.** These are records maintained by each research organization to manage its ongoing DSAM research projects. The records would be sources of project data widely useful to other acquisition professionals such as title, objective, description, status, principle investigator, and research results.

—**Validated DSAM Issues/Problems.** This would be a list of validated and prioritized candidate DSAM issues/problems needing research. The DSAM research organizations, seeking urgent acquisition management prob-

lems to research, would consider these candidates to assure coordination in project selection and avoid wasteful duplication.

—**DSAM Organizations.** These are lists of orgnaizations, including mission descriptions, addresses and contact points involved in or contributing to defense acquisition management.

—**Unabridged DSAM Dictionary.** This would be a centralized file, built upon the integrated DSAM taxonomy-glossary nucleus. It would contain DSAM terms, definitions, acronyms, and synonyms that have been authenticated by, and are used in each military department or agency in DOS. It would include all multiple definitions of each term to indicate potential sources of misunderstandings, and the authenticating authority of each definition to check in efforts toward a common definition.

These highly useful distributed DSAM corporate memory data banks cannot be developed without prior and continuing evolutionary development of the integrated DSAM taxonomy-glossary. A current taxonomy-glossary is required to develop, connect and maintain these data banks as powerful DSAM knowledge, information and communications aids which can help DSAM professionals increase their productivity.

Faced with the huge deficit and inevitable reductions in defense acquisition budgets, we must start immediately developing this prerequisite for a useful acquisition corporate memory with DSAM knowledge systems, which can help professionals increase productivity in defense acquisition substantially and, thus, assure better our adequate defense in the future.

Other DOD Actions

The main purposes of this article are to support the general DOD initiative to provide DSAM knowledge system aids that can help DSAM professionals increase productivity, and to stress urgency for early DOD action to develop the prerequisite DSAM taxonomy-glossary and begin developing acquisition corporate memory data banks connected by DSAM knowledge systems. Equally urgent, however, are concurrent DOD actions supporting the other two general initiatives. To continue increasing productivity in defense acquisition, policy-makers in DOD should begin three other actions immediately.

> Productivity could be substantially increased by instituting an integrated DOD defense acquisition strategy supporting national military strategy.

DOD Acquisition Strategy

The first supports the general initiative to increase integration of major DSAM processes. This action should improve support and coordination throughout the whole DOD program to acquire defense systems. Moreover, during transitions that follow a turnover of administrations and inevitable turnovers of key acquisition policy-makers, this action should assure continuity of useful long-term strategies to assure adequate defense. This action would help the new administration's policy-makers explicitly consider the former administration's acquisition and support strategies—for continuation, cancellation or modification—when developing the new administration's defense acquisition strategy.

In the second article, I discussed policy-maker failures to recognize the generality and power of the strategy concept.[12] It can solve problems of complex acquisition objectives generated by organizations involved in defense acquisition. Now, only program/project managers (PMs) directly managing acquisition of a system are required to develop, maintain and use a formal acquisition strategy. Is this enough? Wouldn't integration of all acquisition strategies in DOD reduce confusion and conflict and, thus, increase overall acquisition productivity?

My research indicates productivity could be substantially increased by instituting an integrated DOD defense acquisition strategy supporting the national military strategy. The Under Secretary of Defense for Acquisition should develop a DOD acquisition strategy, which states DOD goals for defense acquisition and overall DOD strategies to achieve them without known constraints. This would provide long-term strategy guidance to all DOD organizations involved in defense acquisiton—oversight and support organizations, as well as program management organizations.

Commanders/managers of every oversight and support organization in DOD should develop and document their respective organization's strategy for supporting defense acquisitions. Then, these new strategies for supporting defense acquisitions should be integrated with the current PMO acquisition strategies under the DOD acquisition strategy, to form an integrated hierarchy of DOD strategies that support the national military strategy.

For example, in mid-1968, Dr. Robert B. Costello, Under Secretary of Defense for Acquisition, published 10 agenda items for improving defense acquisition.[13] If my reasoning is valid, he should have included the 10 agenda items as parts of a formal DOD acquisition strategy—located at the apex of a hierarchy of PMO system acquisition strategies, and oversight and support organization strategies. Then, PMs would consider the USDA's DOD acquisition strategy in reviewing their respective PMO acquisition strategy documents. Oversight and support organization commanders would con-

sider the DOD acquisition strategy in developing and documenting organization strategies. The USDA would assure all strategies were integrated under DOD acquisition strategy objectives, strategies and constraints—including the 10 agenda items—to support the national military strategy.

Dr. Costello's agenda items would more likely be institutionalized in defense acquisition operations if they were included in an official DOD acquisition strategy. Promulgated by the USDA, effective until amended, and distributed throughout the acquisition community as part of the DOD acquisition strategy, the agendas would get wider dissemination at all working levels and be more permanent. A new USDA would explicitly consider the 10 items in the DOD acquisition strategy and continue, cancel or amend one or more. The new USDA could not just publish a new set of agenda items and let useful old ones die, as my second article shows often happens after turnover of a key policy-maker.

Other strategies that apply to all defense acquisitions, but which concern different key aspects of acquisition, should be included below the USDA stategies at the apex of the integrated DOD acquisition strategy. An example might be DOD-wide strategies based on the new *DOD Contractor Risk Management Guide* to encourage DOD contractors to develop more effective contractor internal control systems and to improve effectiveness and efficiency of DOD oversight. These strategies for assessing effectiveness of a contractor's internal control systems will help determine the extent DOD oversight can be reduced. This will enable DOD to concentrate oversight resources on known problem areas and to focus DOD Inspector General examinations on contractors having questionable internal control systems.

Oversight strategies of each military service should be integrated into the hierarchy below the DOD-wide strategies. One example is the three new Air Force program management policies adopted by the Air Force Systems Command: assure stronger coordination between AFSC and operational user commands; establish new acquisition panels to review AFSC procurement plans of individual program managers; and develop a data base concerning contractor performance to improve assessment of risks involved in source selection. Another is the seven points outlined in a recent memorandum to departments heads in Naval Sea commands, which the Under Secretary of the Navy would like to see emphasized in order to carry out more effective competitive acquisitions. Whenever any strategy developed by and for an individual service would, if applied throughout DOD, increase acquisition productivity in all military services, it should be integrated into the DOD-wide strategies.

When any new strategy is added to the DOD acquisition strategy it should be reviewed with existing strategies to resolve conflicts and assure all strategies are integrated. This will provide integrated guidance to all program managers and support managers for developing their respective program acquisition or support organization strategies, and for integrating them into the DOD acquisition strategy.

Then, each program manager's acquisition strategy and support commander's organization strategy development under the integrated defense acquisition and oversight strategies discussed above can be reviewed, maintained and referenced as integrated elements of the official DOD acquisition strategy.

Research and Information Integration

Another action needed now supports the integration initiative. It is to begin integrating two major processes—DSAM research and DSAM information assembly and dissemination—by systematic use of acquisition corporate memory data banks as they are developed and connected by DSAM knowledge systems. This action will expedite delivery of new DSAM knowledge or information to professionals, speed finding critical voids in DSAM knowledge and information stored in corporate memory data banks, and guide quick filling of these voids through priority DSAM research.

Integrating these acquisition processes to produce an integrated closed-loop research and information (R&I) process[14] would increase productivity in acquisition management. The integrated R&I process would replace three separate traditional processes which, in their overall generation and dissemination of new DSAM knowledge, are poorly coordinated, inefficient and waste resources. The processes are:

—Identifying needs for particular new acquisition management knowledge and information

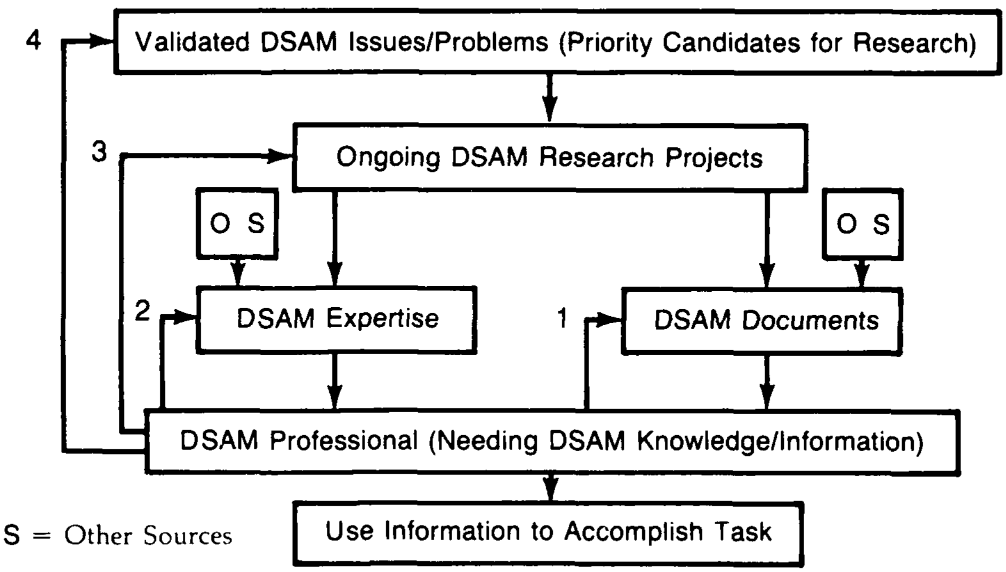
—Conducting research to fill recognized needs for new knowledge and information, and publishing reports of results

—Searching for documented or expert knowledge (old and new) to meet an immediate need for particular job-knowledge, or for specific relevant information to complete a task at hand.

Integrating these separate processes into a more efficent closed-loop R&I process will expedite development and communication of new DSAM knowledge to each professional who needs it, saving time in solving problem tasks, and free scarce DOD resources for high-priority DSAM research. To begin integrating separate processes, DOD should establish now a central DOD validated DSAM issues/problems data bank.

Figure 1 is a simplified diagram for an integrated closed-loop DSAM R&I process that could expedite specific DSAM knowledge or information when either are required by an acquisition professional. The first four large boxes in Figure 1 are four categories of the corporate memory data banks described under DSAM Knowledge Systems. After the data banks of knowledge systems are sufficiently developed to begin operational use, a professional using a system to get particular job-knowledge or task-information would have four options, indicated by numbered arrows.

FIGURE 1. INTEGRATED RESEARCH AND INFORMATION (R&I) PROCESS



O S = Other Sources

The professional may first check, distributed DSAM documents data banks for documented items of the required knowledge/information, and DSAM expertise data banks to locate experts for consultation. If both checks yield nothing, a check of the ongoing DSAM research projects data banks of DSAM research organizations might disclose a principal investigator with the required, but unpublished, knowledge/information.

If all three options are "dry holes," the requirement for particular knowledge/information is entered into the projects-to-be-evaluated file of the validated DSAM issues/problems data bank. After competent authorities validate the professional's requirement and give it a priority, the requirement for research will be transferred to the validated-candidate-projects file with a designated research priority.

Then, any research organization with necessary research expertise and resources, can select a validated high-priority candidate, transfer it to the research organization's own ongoing DSAM research projects data bank, and begin research. After completing the project, the principal investigator would first act as a source of DSAM expertise and give the required new knowledge/information directly to the professional initiating the requirement; then, publish research results to increase the body of DSAM knowledge; finally, add the published report to a DSAM documents data bank for prompt future retrieval when needed.

This simplified explanation indicates the need to begin now preparing to integrate the separate DSAM research and DSAM information-assembly-dissemination processes into a much more efficient closed-loop R&I process. The new integrated process will expedite development of vital new DSAM knowledge, and reduce duplication of research by different research organizations, reducing waste of scarce DOD research resources.

In addition, the explanation illustrates how evolutionary development of DSAM knowledge systems can increase flow of widely useful information throughout the acquisition community. It accentuates the urgency to begin development of the DSAM taxonomy-glossary, a prerequisite to developing and connecting DSAM data banks in the defense acquisition community, making DSAM knowledge systems possible.

Besides supporting the first general initiative to increase integration, acting to integrate the research and information processes will contribute significantly to the second general initiative, constructive change in acquisition management environments. These environments are sources of many problems common throughout defense acquisition. This is evidenced by the fact that most of the 1986 Packard Commission Report was concerned with the defense acquisition management environments, not only with acquisition processes *per se.*[15]

Professionals in the acquisition community, when adversely affected by constraints and waste caused by a particular environment, could use the integrated R&I process to identify specific adverse aspects of an environment that need change. Frequent identification of the same adverse aspect would focus attention and research resou[illegible]s on it as a high-priority candid[illegible] research aimed to change the adv[illegible]vironment constructively. Since most of the Packard Commission Report concerned adverse environments of defense acquisition, I would anticipate numerous identifications of validated candidate research projects for constructive changes in the national security planning and budgeting environment, the government-industry accountability and ethics environment, and the government personnel management and training environment.

Periodic Process Reviews

This DOD action strongly supports the general initiative to manage constructive change of defense acquisition environments. It aims to establish comprehensive periodic defense management reviews of both the acquisition process and its environments. The action concerns long-standing problems with the overall process and structure of defense acquisition management, particularly those arising from its environments. It will involve monitoring progress in solving perennial environment-based problems, and assuring that actions to improve the acquisition environments are tracked, adjusted and sustained until they are institutionalized.

One of the great innovative attributes of the *ad hoc* Packard Commission was the large comprehensive scope of its defense management review. Its domain included specific problems and issues of defense acquisition processes. Additionally, it included problems and issues stemming from the environments of acquisition processes—political, economic and ethical. The Packard Report showed that acquisition environment problems and issues must be dealt with before many specific actions to improve acquisition management can be truly effective.[16]

My research indicates, however, that all *ad hoc* groups by themselves, with no information about progress since the last review and no follow-up reviews, have had three serious insufficiencies for solving complex perennial problems in management of defense acquisition:[17]

—The combined experiential knowledge of all practical size groups like the Packard Commission can never be sufficient to comprehend all aspects of large-scale, complex problems the group is formed to solve.

—The nature of the information available to any group formed in crisis—hastily assembled, incomplete, often irrelevant, a snap-shot of a point in time, and not well tailored to each complex problem considered—is an innately deficient basis for final solutions.

> Reviews should be scheduled every 4 years with reports timed for release before the beginning of each new Administration.

—The "for this time only" nature of *ad hoc* groups, coupled with usual crisis-driven pressures to recommend quick fixes, seldom provides for schedule follow-ups (always desirable for complex problems) in order to make adjustments and assure steady progress on intended improvements.

Yet, despite these insufficiencies, experienced *ad hoc* groups are the best means we know for finding problems and analyzing solutions to complex unstructured defense acquisition management problems. They are effective problem-solvers for each complex interactive problem they address only if they are "knowing" professionals, provided with "right" information, with sufficient time to observe their solution's dynamics.

Sound solutions require overcoming the inherent insufficiencies of *ad hoc* groups. They can be overcome to a significant degree through successive, regularly scheduled, presidential-commission-level reviews of the whole defense acquisition process, including all environments that have a significant impact of acquisition processes. The reviews must be linked over time by relating each succeeding report to the last commission report; i.e., requiring that each report of problems and recommendations include actions to be tracked, progress to be monitored, and information to be continually collected for use in the next schedule review. To provide continuity, each succeeding commission should include a score of the last commission's most effective members.

Reviews should be scheduled every 4 years, with reports timed for release before the beginning of each new Administration. With this timing, each report will support effective transition during inevitable turnovers of defense acquisition policy-makers. Each report should provide current corporate memory information; e.g., information necessary to implement ongoing policy, and information required as background for future decisions. New policy-makers can consider this information against their own prior-experience-based perceptions in deciding what current initiatives to selectively emphasize, continue and institutionalize, and what new initiatives to start.

Based on this reasoning, I believe DOD should begin now—it is already late—to arrange for an immediate presidential-level commission on defense acqusition management. With objectives to continue improving acquisition management, and to increase its productivity in the long run, the next presidential commission should:

—Review progress made since the 1986 Packard Commission Report.

—Consider new acquisition management problems uncovered in current investigations of ethical use of consultants.

—Recommend, as early as possible, further changes needed in acquisition processes and structure, government personnel management systems, the national security planning and budgeting system, and other aspects of the environment within which DSAM processes function and with which they interact.

The report of the 1989 presidential commission could provide to the Bush Administration:

—Useful corporate memory to help new policy-makers maintain, over inevitable turnovers in high-level defense

acquisition managers, truer perceptions of the real environment and acqusition issues that are crucial to defense acqusition and assuring adequate defense.

—A current information base to help new policy-makers decide what initiatives to selectively emphasize and continue, and new ones to start, to substantially increase acquisition productivity in the long-term.

Increasing Productivity

In summary, we urgently need a new engagement to increase productivity of DSAM processes substantially and ensure continuing adequate defense. This new engagement must involve active participation by DSAM professionals at every level of defense acquisition activity in the acquisition community.

Productivity in defense acquisition can be increased substantially by general DOD long-term initiatives supported by DSAM professionals on three fronts. DSAM professional must:

—Continue increasing integration of major DSAM processes

—"Manage" constructive change of defense acquisition environments and motivate development of a culture that is conducive to honest, ethical government-industry teamwork

—Develop DSAM knowledge system aids that can help professionals assemble, structure, inventory, index and store the body of DSAM knowledge/information in acquisition corporate memory data banks; search these data banks, and retrieve timely relevant DSAM knowledge and information when needed in a job or task; and use as truly common DSAM language to communicate with clarity and understanding among themselves and through the media to the public.

The DSAM knowledge systems—with data banks indexed by the common DSAM taxonomy, and interconnected by a common DSAM language rooted in the taxonomy—will aid timely selective access to the body of DSAM knowledge, increase flow of useful DSAM information, improve management communications in the defense acquisition community, and make possible real, long-term progress in the first two general initiatives

We DSAM professionals must continue research and actions to increase defense acquisition productivity and better assure adequate national defense.

This can't be done overnight so the need to start now is urgent! We should begin with prerequisites and concurrent actions on each front that will support best all later actions to continually increase productivity. Specifically, DOD should act immediately to:

—Develop the DSAM taxonomy-glossary—a prerequisite to developing and connecting DSAM knowledge systems required for progress on the other two general initiatives—and, then, continue evolutionary development and use of interconnected data banks of DSAM knowledge systems in support of the long-term DOD initiative to develop DSAM knowledge system aids.

—Develop an integrated DOD acquisition strategy and an integrated closed-loop DSAM research and information (R&I) process, both in support of the DOD initiative to increase integration of major processes.

—Regularly schedule presidential-level commissions, similar to the Packard Commission every 4 years, in support of the DOD initiative to achieve more constructive acquisition environments and a management culture more conducive to government-industry teamwork.

There are other actions that DOD could take immediately under the three long-term initiatives. I have tried to show why the four actions summarized in the previous paragraph are most urgent and should receive highest priority now. As progress is made in evolutionary development of distributed data banks and in interconnecting them through DSAM knowledge systems—and concurrently, in the three proposed actions supporting the other two DOD initiatives—DOD should continue other specific actions on all fronts aimed at assuring continued progress increasing productivity in defense acquisition management. This will better assure continued adequate defense of our freedom to "promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity."

This completes my series, but we DSAM professionals must continue research and actions to increase defense acquisition productivity and better assure adequate national defense. I would appreciate your comments and feedback on the ideas, concepts, and DOD long-term general initiatives and specific actions that I have discussed and proposed in this series. I would appreciate your ideas concerning what emerging information technologies should best support the long-term initiatives, and which technologies should be most useful in specific actions to increase productivity. Working together, we can develop a better roadmap of DOD initiatives and specific actions needed to continue increasing producitivity in defense acquisition to assure continued adequate defense.

Endnotes

1. The acronym DSAM (Defense Systems Acquisition Management) is used in this series to represent both the DSAM process and the body of DSAM knowledge used in managing the process. Both encompass process concepts, functions and related information ranging from managing the acquisition or modernization of a defense system to overall management and support of all defense system acquisitions. Managers at all levels in the DSAM process need aids which can

provide fast, easy, selective access to relevant information in the body of DSAM knowledge.

2. The term DSAM professional, as used in this series, includes any government, contractor, academic or other knowledge worker who uses DSAM knowledge and information professionally in his or her job in support of the defense systems acquisition process—for example, DSAM policy-makers, program/project managers/directors and their staffs, support managers, congressional staffs and members of the Congress, educators, researchers, and DSAM information managers, including librarians who maintain documented DSAM knowledge and know other accessible sources of DSAM knowledge and information for ready access when needed by a professional.

3. Mosier, Andrew P. 1987. "Getting the Jump on DOD Productivity." *Program Manager*: The Journal of the Defense Systems Management College (hereafter referenced as *Program Manager)* (July-August) pp. 18-26.

4. Mosier. 1989. "Past Acquisition Improvements: Not Sufficient." *Program Manager* (May-June) pp. 42-57.

5. Mosier. 1989. "New Initiatives and Concepts for Increasing Acquisition Productivity." *Program Manager* (March-April) pp. 24-34.

6. The term data banks is used in a generic sense in this series to represent all media storing DSAM knowledge and information in corporate memories and knowledge systems including physical document repositories in information centers, full text and bibliographic files in on-line computer data bases, text and graphics on CD-ROM discs or in optical-disc files of juke boxes, and human memories of professionals available for consultation.

7. Taxonomy: Webster's *3rd New International Dictionary* (Unabridged). See also Chrisman, James J., Hofer, Charles W., and Boulton, William R. "Toward a Systems for Classifying Business Strategies." *Academy of Management Review* (July 1988) pp. 413-428. They define taxonomy and discuss objectives and attributes of a classification system and taxa.

8. Distinctions between a discipline and its field, and between fields, can be important in specific taxonomies. Distinctions are best illustrated by examples. Discipline of federal acquisition represents the body of acquisition management knowledge needed for all federal acquisition programs (DOD, DOE, NASA, etc.) including knowledge common to acquisition environments. The field of defense acquisition represents both kinds of common knowledge (general and environments) plus the specialized mission-peculiar (national defense) part of acquisition management knowledge needed only for DOD acquisition programs. Similarly, the field of DOE acquisition or NASA acquisition represents, respectively, both kinds of common knowledge plus the parts of acquisition management knowledge needed only for DOE or NASA acquisition programs. Concepts presented in Article 3 apply to management in general but results of their application in respective federal acquisition fields, except for common general acquisition and federal environments knowledge, will show important differences due to organization- and mission-peculiar factors. The DSAM (Defense-SAM) taxonomy will differ in important details from a DOE- or NASA-SAM taxonomy, but all will have many identical terms; e.g., general acquisition management (research, contracting, accounting), and external environment (public law, federal acquisition regulation (FAR), federal fiscal and personnel management.

9. Hirsch, Edward. 1988. "DOD's Move to a More Professional Acquisition Work Force." *Program Manager* (May-June) pp. 3-8.

10. President's Blue Ribbon Commission on Defense Management. 1986. *A Quest for Excellence: Final Report to the President* (hereafter referenced as *Packard Commission Report)* Washington, D.C.: U.S. Government Printing Office, June, 115 pages. Chapters 1, 2 and 4 show why the defense acquisition environment and its present management culture are crucial impediments to increasing productivity in defense acquisition.

11. Air Force Institutue of Technology (AFIT), School of Systems and Logistics. 1981. *Compendium of Authenticated Systems and Logistics Terms, Definitions and Acronyms.* Wright-Patterson Air Force Base, Ohio: AFIT. 821 pp (AU-AFIT-LS-3-81; DTIC Access Number, ADA 100 655).

12. Mosier. "Past Acquisition Improvements: Not Sufficient," pp. 44-45.

13. Costello, Robert B., 1988. "Ten Agenda Items for Improving Defense Acquisition." *Program Manager* (May-June) pp. 13-15.

14. Mosier. "Past Acquisition Improvements: Not Sufficient," p. 56. See also Mosier, Andrew P., 1985, "A Proposal for Research to Improve the Productivity of Defense System Acquisition Managers throughout Government and Industry." *Proceedings, November 1985 Federal Acquisition Research Symposium*, pp. 9-10.

15. Mosier. "Past Acquisition Improvements: Not Sufficient," pp. 49-50.

16. *Packard Commission Report.* See Endnote 10 and its remarks about Chapters 1, 2, and 4.

17. Mosier. "Past Acquisition Improvement: Not Sufficient," pp. 54-55.

Dr. Mosier, a private consultant, joined the DSMC faculty in 1972 and served in many capacities until retiring in 1983. His career includes experience in military operations, industry, management of military R&D, and in education. He is a retired Air Force officer.

IMPROVING THE PROCESS:

ARE CURRENT MIL-STD-881 PRACTICES A STUMBLING BLOCK TO BETTER PERFORMANCE?

Robert A. Wehrle

So you're going to be a program manager. Hot Dog! Big budgets, people working for you, a chance to do something meaningful something enduring—a chance to fail, end a promising career, or at least reach your terminal rank.

How would you like to build a record as a program manager that rivaled that of John Wooden, coach of the legendary UCLA basketball team that won 10 NCAA titles; or Tom Osbourne, whose Nebraska Corn Huskers have finished in the top 10 in the nation for more than 15 years running; or of Joe Paterno's Nittany Lions who have never had a losing season under his tutelage? How would you like to manage a program that produced a product with quality similar to that produced by the now legendary Japanese manufacturing community?

You can. The tools exist. You've probably used one of them. That's right, you guessed it—the Work Breakdown Structure (WBS).

I know: What's this guy been smoking? But before you toss this aside, let's take a look at what it is that Wooden, Osbourne, Paterno and the Japanese manufacturer have in common. Then if you're still interested, I'll show how that common ground can be used to your advantage as a program manager using, that's right, *the WBS*.

In order to connect the similarities of the Japanese, Wooden, Osbourne and Paterno, we must turn first to the world of statistical quality control. What's that? "Are all these guys QA types?" you ask. In a way, that's exactly right.

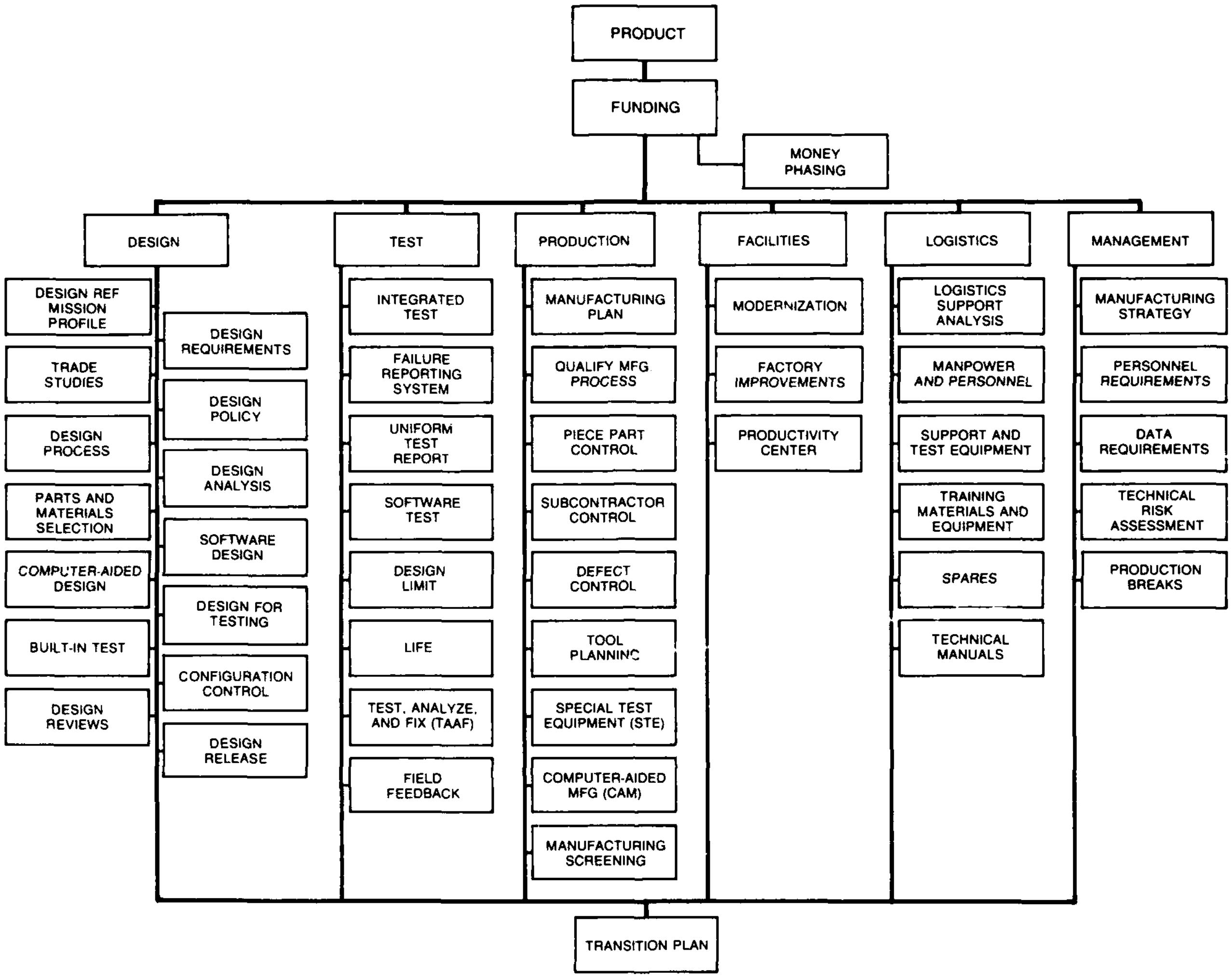
W. Edwards Deming, author of *Out of the Crisis*, (MIT, 1986) argues persuasively that American manufacturers will not be able to compete with the Japanese until they learn the lessons he personally taught the Japanese more than 30 years ago. Dr. Deming was invited to Japan in the early '50s and taught the Japanese his techniques and philosophy for statistical quality control. For his efforts he was awarded the Second Order Medal of the Sacred Treasure by the Emperor of Japan; and the Japanese award "The Deming Award" every year to the company whose product best reflects the proper use of Dr. Deming's philosophy.

With that bit of history in mind, we can turn to one of the fundamental tenets of Dr. Deming's philosophy as a clue to what ties our examples together. Dr. Deming demands that, in order to ensure a quality product, one must, "always and forever," focus on improving the process. If one exercises this discipline, then the product of that process, be it cars, health care, weapons systems, or athletic excellence, will continually improve.

TABLE 1. TYPICAL MIL-STD-881 WBS.

Level 1	Level 2	Level 3
Aircraft system		
	Air vehicle	
		Airframe
		Propulsion unit
		Other propulsion
		Communications
		Navigation/guidance
		Fire control
		Penetration aids
		Reconnaissance equipment
		Automatic flight control
		Central integrated checkout
		Antisubmarine warfare
		Auxiliary electronics equipment
		Armament
		Weapons delivery equipment
		Auxiliary armament/weapons delivery equipment
	Training	
		Equipment
		Services
		Facilities
	Peculiar support equipment	
		Organizational/intermediate (Including equipment common to depot)
		Depot (Only)
	Systems test and evaluation	
		Development test and evaluation
		Operational test and evaluation
		Mockups
		Test and evaluation support
		Test facilities
	System/project management	
		System engineering
		Project management
	Data	
		Technical publications
		Engineering data
		Management data
		Support data
		Data depository
	Operational/site activation	
		Contractor technical support
		Site construction
		Site/ship/vehicle conversion
	Common support equipment	
		Organizational/intermediate (Including equipment common to depot)
		Depot (Only)
	Industrial facilities	
		Construction/conversion/expansion
		Equipment acquisition or modernization
		Maintenance
	Initial spares and initial repair parts	
		(Specify by allowance list, grouping, or hardware element)

FIGURE 1. CRITICAL PATH TEMPLATES



And there we have it ladies and gentlemen, the tie that binds Japanese manufacturers and these successful American coaches—focus on the process.

In his autobiography, *More Than Winning*, (Thomas Nelson Publishers, 1985) Tom Osbourne writes about the "Nebraska Cycle." He analyzes individual aspects of the "process" of producing a high quality product year in and year out. In the chapter "More Than Winning," Osbourne says, "We spend a lot of time trying to talk about process rather than end results...."

John Wooden reportedly said he never talked about winning. Wooden simply told his players that if, at the end of every game each of them could hold their head high and say to themselves that they had played to their maximum potential, then results of their efforts would probably be to their liking. Wooden also stressed fundamentals of the game. He rarely scouted another team because he felt if his team executed the fundamentals well it didn't matter what the other team was doing. In short, Wooden focused on the process, not the end-product.

Joe Paterno's philosophy on winning closely resembles that of Osbourne and Wooden. He says, "The will to win is important, but the will to prepare is vital." Again, focus on the process, not the product.

"OK!" you say, "Focus on the process, but what in the world has that got to do with a WBS?" Everything, my friend, *everything*.

First, let's look at a typical WBS structure as outlined in MIL-STD-881 Work Breakdown Structures (Table 1). The example provided here is typical of the WBS structures found in MIL-STD-881; that is, they are all focused on the end-products of a process rather than on the process for achieving an end-product.

We are a product-oriented society and our methodologies and tools reflect that. Notice that the WBS shown in Table 1 focuses almost exclusively on end-products at all the levels shown. When the costs for the lower levels of the WBS are rolled up

to the next level the result is data focused solely on the individual components of the system. If a manager attempts to make cost-cutting decisions based on this data, his attention will be focused entirely on the end-product of the process and all detail concerning the process is lost.

If we accept Dr. Deming's philosophy as so ably practiced by the Japanese, Osbourne, Paterno and Wooden, then how can we use the WBS to focus on the process rather than the product? Before answering that question let's briefly examine whether or not "focus on the process" is a new and novel idea in the Department of Defense.

As it turns out, focus on the process is not an idea alien to the Department of Defense. The DOD 4245.7, "Transition from Development to Production," and its companion manual, institutionalize the requirement to focus on the process and have been around since 1984. In the preface to the manual, W.J. Wiloughby, Jr., writes, "We must strive for improvement in the understanding and the timing of the disciplines of design, test, and production." (Replace the word "discipline" with the word "process." Interesting, isn't it?)

The Department of the Navy has produced its version of the DOD manual *Best Practices* (NAVSO P-6071). The Navy manual uses the DOD product template (see Figure 1) as a departure point. Then, for each element of the template, the current approach, best practices and major traps for that element are summarized. The document is easy to read and provides a broad and thorough coverage of product design and manufacture.

The MIL-STD is long overdue for a revision. It was originally written in November '68 and last revised in April '75. Rewriting the MIL-STD should be straightforward.

Recent RFPs have included requirements for contractors to demonstrate how they are going to use Taguchi methods for quality control. Mr. Taguchi is a disciple of Dr. Deming; thus, this requirement is really a requirement for contractors to demonstrate how they are going to use Taguchi methods for improving their manufacturing processes.

Now, look at Figure 1 again, and let's answer the question about how we can reorganize a WBS to help focus on the process. Imagine, if you will, a WBS structured around the product template just discussed. The WBS level 1 is the product, level 2 the major design process elements, level 3 the sub elements of each major design process element, etc. Can you see how a manager's attention would be focused exclusively on the process if such a WBS were used? At lower levels, details for each piece of hardware and software are captured. Now as the WBS is rolled up, the view is increasingly focused on the important aspects of the design process—not the product.

Focusing on the process is a practice whose time has come. Unfortunately, MIL-STD-881 institutionalizes a focus on the end-product. The MIL-STD is long overdue for a revision. It was originally written in November '68 and last revised in April '75. Rewriting the MIL-STD should be straightforward. The separate WBSs for individual weapons systems should be replaced with the generic WBS template already discussed. In this day and age of trying to lighten the specification load, this idea should be implemented at once.

It's clear that focusing on the process is a philosophy that is not new to the Department of Defense. The DOD and individual Service directives, as well as recent RFPs, are clear evidence that this approach is considered appropriate for use in the acquisition community.

The MIL-STD-881 should be updated to reflect this focus on the process. Until then, the program managers are forced to use a tool at odds with the directives they are trying to implement.

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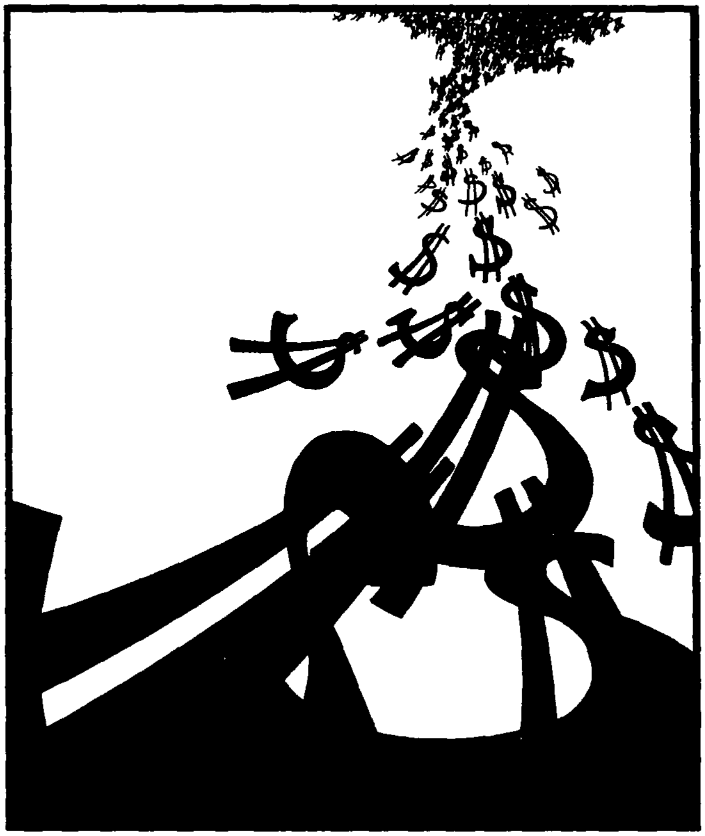
COST RECOVERY:
INDEPENDENT RESEARCH AND DEVELOPMENT BID AND PROPOSAL EXPENSES

Paul Stein



There is no comprehensive general information pamphlet available on Independent Research and Development and Bid and Proposal Cost (IR&D/B&P). There is guidance available to defense industry contractors on advance agreements from their lead negotiation agencies. There is limited information available for small contractors not required to negotiate an advance agreement.

As a former Department of Defense auditor, I have encountered problems in dealing with small contractors in issues involving IR&D/B&P costs. At one site, the contractor was shocked to learn that direct IR&D/B&P costs must be allocated a full share of burden (but no G&A, general and administrative). At a second site, a newly incorporated contractor received a major cost plus fixed fee contract. The contractor immediately hired a B&P army to develop a major contract base. The contractor operated on the premise that the tremendous B&P expense would be paid for under the cost type contract. The contractor went bankrupt, eventually pleading guilty to fraud (much of it involving bid and proposal fraud).

The IR&D/B&P cost recovery under DOD regulations, is a unique and complex area. To appreciate, in a quick way, the complexity of the area consider the following four items.

—The IR&D/B&P direct costs are accumulated by individual project and charged direct. They are allocated a full share of burden (excluding G&A). These direct costs (with burden) then flip-flop and become indirect costs, which are then usually allocated over the G&A base, as a G&A type cost. Since they are allocated over the G&A base, they must be removed from the G&A base.

—Direct IR&D/B&P costs remain in their individual bases (engineering direct labor) for the purpose of computing the primary cost centers' overhead rates, yet are excluded from the G&A base when the G&A computation is made.

—DOD Cost Accounting Standard (CAS) Working Group Guidance No. 77-11, dated February 2, 1977, stated IR&D/B&P costs remain in the G&A base and are not transferred to the G&A pool, when an allocation base other than the G&A base is approved for allocation of IR&D/B&P. When IR&D/B&P costs are included in the G&A base, the contractor allocates and is paid G&A on the gross amount of IR&D/B&P, not on the allowable amount. This prevented the contractor from being denied G&A reimbursement, when there were unallowable I&D/B&P costs in the G&A base. With all other unallowable base costs, the contractor must allocate (and lose) G&A allocable to unallowable base

costs. The W.G. item was significant when published.[1] It is commonly assumed that W.G. 21 guidance is still applicable; with publication of CAS 420 (on IR&D/B&P) in 1980 with its provision for special allocations, the above guidance became obsolete. However, leading contractor consultants/seminar lecturers/textbook publishers are still teaching/publishing the obsolete and now incorrect guidance.

—The DCAA Contract Audit Manual (CAM) gave wrong guidance in the form of incorrect calculations to its auditors in the December 1987 CAM edition. The error was corrected in the July 1988 version.

I wrote this paper to aid the reader needing to be educated (quickly) on the IR&D/B&P cost recovery process in the defense industry. With the DCAA and noted consultants providing and publishing erroneous examples in manuals/textbooks, the complexity of the area and need for factual updated material is evident.

Independent Research and Development and Bid and Proposal Costs

Why does the government pay for contractor IR&D programs? "The program is recognized by DOD as a cost of doing business, necessary to retain a competitive source of technically capable bidders responsive to DOD requirements. The DOD reported in FYs 1984 and 1985 that 269 major companies/divisions incurred costs of $10.2 billion for program efforts and $4.0 billion for bid and proposal efforts. For program (I&D) efforts...DOD paid $4.0 billion of the $10.2 billion."[2] In addition to promoting a strong defense base, under the complex reimbursement formula, DOD receives potential benefits several times in excess of actual DOD expenditures. Support for the IR&D/B&P program is not unanimous. David Chu, DOD Director for Program Analysis and Evaluation, proposed eliminating the IR&D/B&P program as too costly. The success of that proposal is remote.[3]

IR&D/B&P Costs—Defined

A contractor's independent research and develoment (IR&D) is technical effort not sponsored by a grant or required in performance of a contract. The IR&D projects fall within three areas: basic and applied research, development, and systems and other concept formulation studies. Bid and Proposal costs ar expenses incurred in submitting, and supporting bids and proposals on potential government and non-government contracts. The FAR cost principle 31.205-18 and the DOD FAR Supplement 231.205-18 address these costs.[4,5]

Establishment and Structure Of Current IR&D Program

The DOD Instruction 3204.1, "Independent Research and Development," December 1983, established policies and responsibilities for administering the program. The instruction established the Technical Evaluation Group (TEG) and Tri-Service Negotiation Group (TSNG). The TEG includes a technical manager representing each Service and a representative from the Under Secretary of Defense (Acquisition). Within each Service, responsibility for technical evaluation process is delegated based on the organization's area of expertise. That organization is responsible for coordinating the submission of technical evaluations by DOD personnel, compiling an overall technical quality rating for the company based on evaluations submitted, and presenting a summary report to the Service(s) technical manager(s). The Tri-Service negotiation group includes senior negotiators representing each Service and a representative from the Assistant Secretary of Defense (Production and Logistics)."[6]

Advance Agreements—Major Contractors

Section 203 of Public Law 91-441 and FAR 31.205-18 require any company receiving payments in excess of $4.4 million from DOD for IR&D/B&P in a fiscal year to negotiate an advance agreement establishing a ceiling for allowability of IR&D/B&P costs for the following fiscal year. The $4.4 million criteria includes only recoverable (allowable) IR&D/B&P costs allocated during the company's previous fiscal year to all DOD prime contacts and subcontracts for which the submission and certification of cost and pricing data were required in accordance with Section 2306(f) of Title 10, United Staes Code (USC) (Truth in Negotiations Act).[7,8]

Potential Military Relevancy. Section 203 of the DOD Military Procurement Authorization Act of 1971 requires that I&D/B&P payments by the DOD be made only for work that has a potential military relationship (PMR).[9,10,11]

Evaluation Procedures. Contractors meeting the requirements for a mandatory advance agreement must initiate negotiations before the end of the fiscal year for which the agreement is required. The agency designated responsibility for a specific contractor will furnish the contractors with guidance on technical and financial information needed to support IR&D/B&P proposals. Generally, the agency providing the largest share of the contractor's government sales will be the designated agency. The Army, Navy, and Air Force negotiate the majority of required agreements. The DLA is assigned responsibility to negotiate advance agreements by mutual consent of the three military services. A listing of contractors and organizations assigned responsibility is maintained by the DOD Indirect Cost Monitoring Office. The IR&D/B&P negotiations, including any CAS 420 issues, are handled by the Tri-Service contracting officer (TSCO). The designated DLA administrating conracting officer handles DLA designated negotiations. Before start of the contractor fiscal year, the contractor furnishes the IR&D manager of the lead department for technical evaluation brief descriptions of IR&D projects planned for the year, including relevant technical and financial information in accordance with guidance furnished by the IR&D Technical Evaluation Group for IR&D, and the cognizant Tri-Service Departmental Office for bid and proposal. Contractors not assigned for IR&D and B&P negotiations on the master list of contractors for negotiated indirect cost rates and

advance agreements for IR&D and B&P costs will be handled by the department having the preponderance of contracts and subcontracts performed.[12,13,14]

Additional Dispute De Facto Penalty for Continuing Protest. Contractors continuing to dispute PMR findings, or any findings causing a problem in negotiating an advance agreement, face a significant penalty. The FAR 31.205-18(c)(v) provides that if no advance agreement is reached, payment for IR&D/B&P costs shall be reduced to an amount not to exceed 75 percent of the amount that, in the opinion of the contracting officer, the contractor would have been entitled to receive under an advance agreement. Negotiations must be concluded before completion of the year under negotiation. The contractor may file an administrative appeal to a board established by the lead negotiating agency.[15,16,17,18]

Advance Agreement Negotiations Not Initiated. No IR&D/B&P payments shall be allowable if a company fails to initiate negotiation of a required advance agreement before the end of the fiscal year for which the agreement is required.[19]

Separate Dollar Ceilings Negotiated for IR&D/B&P. Separate dollar ceilings shall be negotiated for both IR&D/B&P costs. For incurred cost purposes, the ceilings are interchangeable.[20,21]

Advance Agreement Not Applicable to Foreign Military Sales. The negotiated ceilings apply to DOD contracts for domestic requirements. Contracts for foreign military sales are allocated a full (reasonable) share of IR&D/B&P costs (but see next paragraph).[22,23]

Over the Ceiling/Ceiling. To ensure a reasonable allocation of costs, secondary ceilings are sometimes imposed on FMS contractors. Secondary ceilings limit IR&D/B&P expenditures to an amount in excess of the ceiling used for domestic contracts. This concept appears to be discretionary.

Accounting for IR&D and B&P. The FAR requires that IR&D and B&P costs include all direct and all allocable indirect costs determined on the same basis as if the projects are under contract (excluding G&A). The B&P costs include all costs incurred in preparing, submitting, and supporting bids and proposals.[24,25]

The B&P project costs shall include costs which, if incurred in like circumstances for a final cost objective, would be treated as direct costs of that final cost objective.

The B&P costs include those for technical personnel engaged in the preparation and publication of costs and other administrative data necessary to support the contractor's bids and proposals. Cost of technical personnel engaged in the development and preparation of the technical proposal document should be separately identified and classified as direct B&P cost subject to full burdening.

As a general rule, IR&D/B&P costs will be allocated to contracts on the same basis as the G&A expenses. The contracting officer may approve the use of a special allocation method, when allocation through the G&A base does not provide equitable allocation.[26]

Direct Charging IR&D/B&P. Although B&P is generally allocated to contracts over the G&A base and is therefore an indirect cost, Interpretation No. 1 to FAR 30-402 states that B&P will be a direct contract charge when a contractual requirement requires the contractor to prepare, submit, and support a proposal for follow-on effort.[27]

The Proposal. Contractor proposals for advance agreements should be reviewed to the same extent as any other proposal. The results of the review should provide the latest available cost (including reasonable estimates), data for the current fiscal year, including comparison to budgeted data; acceptability of the contractor's allocation procedure; the extent of contractor control over IR&D/B&P costs through budgets; and changes in the contractor's business base.[28]

The Negotiation. The designated TSCO (or DLA ACO) shall consider:

—"Comparison with previous year's program, including the level of government participation

—"Changes in the company's current business activities and projected future business activities, to the extent these future activities can be determined with reasonable certainty

—"The results of the technical evaluation of IR&D

—"The extent to which the B&P program is well planned and managed

—"The determination concerning the company's IR&D/B&P projects and any agency rules on allowability."[29]

Forward Pricing/Interim Billing. The FAR provides that forward pricing and interim billing factors for IR&D/B&P will be developed by and obtained from the cognizant central office of the department responsible for negotiating the advance agreement.[30]

Monitoring IR&D/B&P Costs. Events occuring during or subsequent to the rate negotiation may impact allowable IR&D/B&P costs. The lead negotiator should be informed if significant changes occur. The cost monitor should be alert to the following.

—*Underrun of Planned Expenditures.* Expected IR&D/B&P will be lower than expected because of planned reductions.

—*Changed IR&D/B&P Priorities.* Contractor's initiate new projects, delete planned projects. This may impact PMR.

—*Potential for Labor Mischarging.* The ceiling creates a form of firm-fixed-priced contract (at the ceiling level). Charging IR&D/B&P in excess of the ceiling is equivalent to an overrun on a firm-fixed-price contract. Some contractors may be motivated to charge labor to indirect cost accounts (i.e., waiting for work, training) or to other contracts when an overrun appears inevitable. Contractors may be motivated to charge/transfer costs of mediocre projects from IR&D to B&P to avoid low technical ratings. Making analysis more difficult are technical

TABLE 1. VARIOUS LEVELS

Assumptions	Ceiling(1) Negotiated	Cost Incurred Relevant	Non-Relevant	Total
IR&D/B&P	$15,000	$11,750	$3,750	$15,500

DOD Participation(2)	IR&D/B&P Allocable Amounts	Allowable Amounts(3)
100%	$15,500	$11,750 ($15,000)*
90%	13,950	11,750 (13,500)*
80%	12,400	11,750 (12,000)*
70%	10,850	10,500 (10,500)*
60%	9,300	9,000 (9,000)*
50%	7,750	7,500 (7,500)*
40%	6,200	6,000 (6,000)*
30%	4,650	4,500 (4,500)*
20%	3,100	3,000 (3,000)*
10%	1,550	1,500 (1,500)*

1. The ceiling is the maximum amount allowable for allocation to work covered by the advance agreement.

2. The level of DOD participation determines amounts allocable to DOD contracts. This amount may be greater than the allowable amount.

3. The total allocated to DOD shall not exceed the total of expenditures for relevant projects. The allowable amount is the lesser of the PMR amount, or the allocable amount based on the DOD participation level, after adjustment to the negotiated ceiling (the product * of the negotiated ceiling times the DOD participation rate). For example, at an 80% DOD participation rate, the product is $12,000, and the PMR amount is $11,750. Therefore, the allowable amount is $11,750 (see comment in reference table).[31]

judgment calls necessary in evaluating projects. The types of effort performed under a contractor's IR&D projects, its R&D contracts, its CIP (government funded programs to improve the contractor's processes), and manufacturing and production engineering costs (FAR 31.205-25) may be so closely related as to blur the distinction among types of effort.

Analysis of Year End Data. At the completion of the fiscal year, the actual incurred cost should be summarized for comparison to the negotiated ceiling and to determine the final amount payable. Table 1, based on an illustration in the Defense Contract Audit Manual, July 1988 (DCAAM 7640.1), illustrates the determination of IR&D/B&P cost allowability at various levels of DOD participation.

When an Advance Agreement Is Not Required. When the threshhold for advance agreements is not reached, the FAR 31.205-18 cost principle prescribes a formula for determining the maximum payable. This FAR cost principle does not require PMR. The PMR requirement is a DFAR requirement and applies to contractors required to negotiate advance agreements.

Under the cost principle, a ceiling is determined based on the contractor's prior three-year experience. The two highest expenditure years are used in the calculation. Two separate calculations are made. Under the first calculation, the maximum amount payable is based on the ratio of historical IR&D/B&P expenditures to sales. This ratio is then applied to the year being negotiated. The product is the maximum payable under the ratio method. Under the second calculation, the amount payable is based on the dollar average of the two highest years. Using this dollar average, both a ceiling and floor are computed. Payment will be based on the ratio method. However, when the reimbursement under the ratio method (method one), exceeds the ceiling or falls below the floor (method two), reimbursment is based on method two. One combined calculation for IR&D/B&P is made.

Table 2 illutrates the procedure.

Why Compute a Floor? The floor concept was established to make certain that the contractor receives sufficient IR&D/B&P funding in difficult economic times (when the contractor's industry is in a slump, sales may be abnormally low). Applying the historical ratio to the low sales base will result in a low ceiling. Therefore, at precisely the time the contractor most needs to spend funds on IR&D/B&P, reimbursement is reduced. The floor calculation allows the contractor additional reimbursement in these situations. The contractor is reimbursed the greater of the historical ratio or the floor.

TABLE 2. AN ILLUSTRATION

	IR&D/B&P Costs		
	Sales(1)	Incurred(2)	Ratio
	$	$	%
1975	$ 671,119	$ 38,551*	5.74*
1976	1,158,114	31,981	2.76
1977	2,219,239	91,021*	4.10*
1978	3,576,283	153,331	

* Highest

Average Historical Ratio: 5.74% + 4.10% = 9.84%/2 = 4.92%.
Average Annual Cost: $ 38,551 + $ 91,021 = $129,572/2 = $ 64,786.

Product of historical ratio application:

4.92% * $3,576,283 $175,953

The maximum payable under the historical ratio is $175,953.

Dollar average method:

120% of average annual cost (ceiling) $ 77,743
80% of average annual cost (floor) 51,829

Comparison of method one to method two.

Method one reimbursement $ 175,953

Method two reimbursement $ 77,743

Amount payable $77,743. Reimbursement is therefore limited to the lesser of the historical ratio or the ceiling.

The ceiling concept is meant to prevent a contractor from using a government contract base to dramatically increase IR&D/B&P expenditures.

Assume estimated sales are $500,000. Product of historical ratio application:

4.92% * $500,000—$24,600.

The maximum payable under the historical ratio is $24,600. However, the floor is $51,829. The government pays $51,829.

Discretion? The contracting officer has discretion to establish a ceiling in excess of formula results. In an Armed Services Board of Contract Appeals case (ASBCA No. 23463, July 25, 1980, Dynatrend Incorporated), a contractor with an expanding business base and a well managed IR&D program was denied reimbursement in excess of the formua ceiling. The court ruled in favor of the contractor and awarded "all the reasonable, allowable and allocable B&P cost." The use of discretion is mandated, when warranted. The dollar amounts in the above illustration are from that case. The administrating contracting officer's failure to consider additional reimbursement was considered an abuse of discretion.[32]

Must an "Advanced" Agreement Be Made in Advance? This is a controversial and sensitive question. The FAR 31.205-18(c)(2)(iv) reads "at the discretion of the contracting officer, an advance agreement may be negotiated when the contractor can demonstrate that the formula would produce a clearly inequitable cost recov ry." My research disclosed the contractor's failure to request an advance agreement in advance of expenditures, and even before expiration of the contractors fiscal year, does not necessarily bar a contractor from recovery in excess of the formula maximum. On two occasions in 1978, the Office of the Under Secretary of Defense for Research and Engineering instructed ACOs to allow after-the-fact IR&D B&P costs for smaller contractors not required to negotiate advanced agreements. Local DOD representatives are still grappling with this issue. Field replies to HQ agencies still request guidance in this area. Recommendations from the field include requests to clarify the language in FAR.

Disturbi , Trends. Responses from the field indicate that some DOD consultants are keying in on the confusion surrounding the requirement (or lack thereof) for obtaining an advance agreement. With DOD budget constraints, and fewer contract awards, small contractors are being advised to increase B&P expenditures and not worry about the formula ceiling and

lack of an advanced agreement. It should be noted that the area in question is limited to situations where an advance agreement is not required (FAR 31.205-18(c)(2) type costs).

Current Status of IR&D/B&P. The FY 1988 IR&D/B&P ceiling was set at $5,634,013,000. This reflected an increase of 3.5 percent above the 1977 ceiling for inflation and 2.2 percent for new companies meeting the threshold requirements for advance agreements.

The DOD Inspector General, in a 1987 report, said the DOD system is generally effective; however, the Services were criticized for not having uniform methods of computing the prenegotiation cost objectives for negotiating program advance agreements; not having effective procedures for screening projects for PMR; and not receiving full benefit of the data on file in the Defense Technical Information Center. The main thrust of the IG report was the need for improved reviews of PMR. In a significant comment, the IG said "since DOD reimburses a pro rata share (based on the ratio of DOD to commercial work) of program cost up to the cost ceiling, DOD reimbursements will be inappropriately increased if projects without military relevance are included in the cost ceiling; therefore, we believe DOD should only participate in a company's cost pool for military projects."[33]

Contractor personnel have waged a lengthy battle to "enhance" the IR&D/B&P process. Contractor estimates are that 5 percent of the total amount of funding spent on IR&D is used to prepare task descriptions of proposed projects. They claim federal budgetary limitations prevent any real increases in IR&D funding. Another major contractor complaint is that the process forces contractors to subsidize the government IR&D effort. Their rationale is that the combination of the ceiling limitation and PMR requirements prevent contractors from recovering a fair share of IR&D expenditures. For 1984-85, 70 percent of total IR&D costs was allocated to DOD and 54 percent of the allocated amount was paid by DOD.

Endnotes

1. DOD Working Group Item -77-11, "Interim Guidance for the Implementation of CAS 410, Allocation of Business Unit General and Administrative Expenses to Final Cost Objectives, W.G. 77-11, February 2, 1977. This W.G. item provides DOD guidance on G&A and IR&D/B&P.

2. DOD IG Audit Report No. 88-025, "DOD Administration of the Independent Research and Development Program," October 13, 1987.

3. *The Government Contractor,* Federal Publications, June 1988.

4. FAR 31.205-18, "Independent Research and Development and Bid and Proposal Costs," is the cost principle on IR&D/B&P.

5. 1988 Edition DFAR 231.205-18, "Independent Research and Development and Bid and Proposal Costs," is the DOD supplement to the FAR cost principle.

6. DOD IG Audit Report 88-025.

7. 1988 DFAR 231.205-18.

8. *Contracting with the Federal Government,* Price Waterhouse, 1984, John Wiley and Sons Pub.

9. 1988 Ed. DFAR 231.205-18.

10. Audit Rpt. 88-025.

11, FAR 42.10, "Negotiating Advance Agreements for Independent Research and Development Bid and Proposal Costs," provides guidance in IR&D/B&P area.

12. Rpt. 88-025.

13. FAR 42.10.

14. DFAR 242.10, "Negotiating Advance Agreements for Independent Research and Develoment/Bid and Proposal Costs," is DOD supplement to the FAR cost principle.

15. FAR 31.205-18.

16. 1988 Ed., DFAR 231.205-18.

17. FAR 42.10.

18. DFAR 242.10.

19. FAR 31.205-18.

20. FAR 42.10.

21. DFAR 242.10.

22. Ibid.

23. DFAR 225.7304(D)(iv)(3), "Pricing Acquisitions for Foreign Military Sales (FMS)," provides special DOD guidance in the FMS area.

24. FAR 31.205-18.

25. FAR 30.420 (CAS), "Accounting for Independent Research and Development Costs and Bid and Proposal Cost," is the cost accounting standard on IR&D/B&P.

26. Ibid.

27. FAR 30.402 (CAS), "Consistency in Allocating Costs Incurred for the Same Purpose." This standard contains interpretation No. 1, which provides for direct charging of B&P in specified situations.

28. Defense Contract Audit Agency Manual (DCAAM 7640.1) December 1987 and the July 1988 Revision. Section II, paragraph 16, is the corrected DCAAM illustration table. While researching material for this paper, I determined the actual table in the DCAAM 7640.1, December 1987 Revision, was incorrectly calculated. I discussed the error with DCAA HQ personnel. The DCAA confirmed the error and said they would (and did) correct the error in their July 1988 revision. This comment is made in an effort to prevent confusion on the part of those who reference the December 1987 DCAAM. I consider the DCAAM an outstanding and highly reliable source of information.

29. FAR 42.10.

30. Ibid.

31. DCAAM 7640.1, December 1987 and July 1988 Revision.

32. ASBCA Case No. 23463, July 25, 1980, Dynatrend Inc., provides insight into the use of contracting officer "discretion," in determining IR&D/B&P ceiling.

33. *Accounting for Government Contracts. Cost Accounting Standards,* Lane Anderson 1988, Matthew Bender, Pub.

Mr. Stein is Assistant Professor of quantitative management, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

PRODUCTION COMPETITION

LESSONS-LEARNED: INCUMBENT CONTRACTOR TORPEDOES

Bill Drinnon
David Hodulich

Official U.S. Navy Photograph

The Tomahawk Cruise missile breaks from the water after a sub-service launch. The Tomahawk production competition has provided valuable lessons-learned and substantial savings.

During the past several years, we learned much about establishing competitive production sources for defense systems. We had direct contact with some two dozen programs as a result of our:

—Support of Army, Navy, and Air Force program managers.

—Assistance to defense contractors in capturing second-source programs.

—Work with DSMC in developing their production competition handbook (*Establishing Competitive Production Sources*) and a production competition course.

—Association with the Navy Competition Advocate General in developing *The Competition Handbook* and several program histories.

We gained passing knowledge of additional competitive programs as a result of teaching the Production Competition Course to more than 1,200 people involved with planning and implementing competition in DOD programs.

We have put together a series of observations and lessons-learned gleaned from our experience. This first article describes what incumbents do when program managers move to compete previously sole-source programs.

Sole-source incumbents quite understandably do what they can to sink government initiatives to compete their programs. They employ cost effectiveness and industrial base arguments to kill the competition outright and, failing in that effort, take actions to delay the competition and damage the second source's competitiveness.

Cost Effectiveness Arguments

Incumbents will begin by asserting that competition is in fact not cost effective. Economic models are easily misused if the analyst applies incorrect, inaccurate, or otherwise inappropriate estimates for critical input parameters. Incumbents understand this and have access to the same model used by the government and potential second sources. Thus, it is easy for incumbents to develop analyses that favor continued sole-source procurement.

In bolstering their argument that competition is not cost effective, incumbents will assert that splitting production between two sources will require both contractors to produce below efficient production rates. This, sole-source contractors say, will result in increased prices and, in the extreme, contractors leaving the market when forced to produce below their minimum sustaining rate.

If the government still believes that competition will be cost effective and continues to move toward competition despite the above arguments, incumbent contractors will offer alternative (lower cost) sole-source acquisition strategies. These strategies require the government to abandon its competition plans and help the sole source reduce its costs. These reduced costs would then be passed along to the government in the form of reduced prices, which would be lower than prices under competition, the incumbents claim. Specifically, the incumbent contractor will

want the government to redirect its investment from the competition program to a more efficient sole-source alternative. For example, the incumbent will propose that the government provide:

—A more efficient production schedule

—Multiyear contracts

—Funds to establish increased sub-tier competition

—Funds for plant modernization programs.

If the government remains unconvinced that continuing sole source with the incumbent contractor is in its best interest, incumbent contractors will often offer to "buy" the sole-source program. Here, in exchange for the government dropping its second-sourcing plans, the incumbent guarantees lower prices to be achieved through:

—Reduced profit and overhead

—Increased corporate investment in cost-reducing capital equipment

—Improved make-buy planning

—Increased incumbent-financed sub-tier competition.

Typically, as part of its offer to buy the sole-source program, the incumbent will guarantee reduced prices for several years with firm fixed price contract options. The government understands, however, that once the competition initiative is dead, design and quantity changes may nullify these guarantees. Accordingly, to overcome government skepticism about the incumbent's willingness and ability to reduce prices in a non-competitive environment, and to put teeth into long-term price guarantees, incumbents may propose two additional options.

—A firm fixed price option for a production-quality, restriction-free technical data package. This option would be exercised at govenment discretion if the incumbent failed to meet specified cost, schedule or technical requirements.

A firm fixed price option for a leader-follower program also would be exercised at government discretion if the contractor failed to meet specified conditions.

Incumbents may resort to what amounts to predatory pricing. In such cases, the first source makes the government "an offer it cannot refuse" for 100 percent of the instant year's buy.

These options, incumbents assert, provide the government with alternative *threats* of competition, in place of *actual* competitive forces that would have been provided by an in-place competitive producer.

It should be noted that incumbents have attempted to "buy" sole-source programs even after the government has begun its competition program. Although potential second sources view such strategy changes as unfair, the government, in the past, has canceled competitions and accepted incumbent's alternative sole-source acquisition strategies.

Industrial Base Arguments

As mentioned, the incumbent can be expected to argue his minimum sustaining rate is greater than that available to him if competition is established. Accordingly, the incumbent will announce he will be forced to leave the market if competition is established.

The incumbent will assert there are less dramatic (and more believable) long-term economic consequences. For example, if forced to lower price and share quantity with a competitor, it follows that the incumbent will have fewer dollars to invest in personnel, facilities, and future government research and development efforts.

These arguments often find a sympathetic ear within the government.

Tactics to Delay Competition

An incumbent faced with competition on a currently sole-source program will take a variety of actions to delay the first competitive buy. His objectives are to:

—Produce as many units sole source as possible

—Put the second source at a competitive disadvantage

—Keep alive the possibility of killing the competition initiative.

The incumbent can delay the first competitive buy in several ways. He can delay responding to government RFPs for data or assistance to the second source. The incumbent can accelerate change proposals, which would force the government to revisit the competition decision, increase the second source's production qualification problems, and confuse the situation in general. Incumbents can deliver incomplete, incorrect, or misleading design information for use by the second source. Incumbents can deliver data and qualification kits late, again delaying second-source production qualification.

Tactics to Damage the Second Source

If the competition initiative is not killed early on, the incumbent will take action to damage the competitiveness of potential competitors. For example, simply continuing the delaying tactics discussed can put the second source at a distinct disadvantage for the first competitive buy.

Another way to gain an advantage over the new competitor is to force him to invest heavily. The incumbent can do this by obstructing common use of

Official U.S. Air Force Photo

Close-up view of an AIM-9L Sidewinder missile mounted on wingtip of an F-16 Fighting Falcon aircraft. The Sidewinder has been produced competitively for many years.

special tooling and test equipment, promoting an artifically long technology transfer and production qualification process, and refusing to provide lower-tier source information.

Incumbents will try to minimize production quantities available to the second source. They will often accomplish this by promoting schedules that spread small qualification and initial production buys over several years (while the incumbent is producing large quantities sole source). Another way to minimize second-source quantities is for the first source to convince the government of his very high "minimum sustaining rate." The first source can then negotiate quantity guarantees that leave only small quantities subject to annual competition.

Incumbents may resort to what amounts to predatory pricing. In such cases, the first source makes the government "an offer it cannot refuse" for 100 percent of the instant year's buy. If the offer is accepted (as has happened), the second source may not be able to compete for subsequent buys.

Conclusion

These arguments and tactics are *always* employed and are *often* successful in killing or delaying competition. The government and potential second sources must be ready to counter these "torpedoes" with well-thought-out analyses and plans.

Mr. Drinnon and Mr. Hodulich are associated with LDI, Incorporated, a consulting firm specializing in weapon system acquisition planning.

Doctor Waelchli (1934-1989)

In Memoriam

Dr. Fred E. Waelchli suffered a heart attack March 6, 1989, in his office at the Defense Systems Management College and was taken to DeWitt Army Hospital, Fort Belvoir, where he was pronounced dead. Several hundred people attended a memorial service March 10 at the Fort Belvoir Post Chapel. The eulogy was given by the DSMC Provost, Mr. Gregory T. Wierzbicki. Scripture readings were given by Dr. Benjamin Rush, Director, and Commander John Hutchins, USN, both of the DSMC Business Management Department, where Dr. Waelchli was a Professor of Management. He also was a member of the DSMC Center for Acquisition Policy, and a frequent contributor to *Program Manager*.

Joined DSMC in 1979

Dr. Waelchli joined the DSMC faculty in July 1979 and taught Federal Financial Management, Business Management Department (BMD) through 1983. He then taught Management Techniques and Acquisition Policy, Policy and Organization Management Department, for 2-1/2 years. In July 1986, Dr. Waelchli returned to BMD and, in October 1987, accepted an additional appointment as Associate in the newly-formed DSMC Center for Acquisition Management Policy.

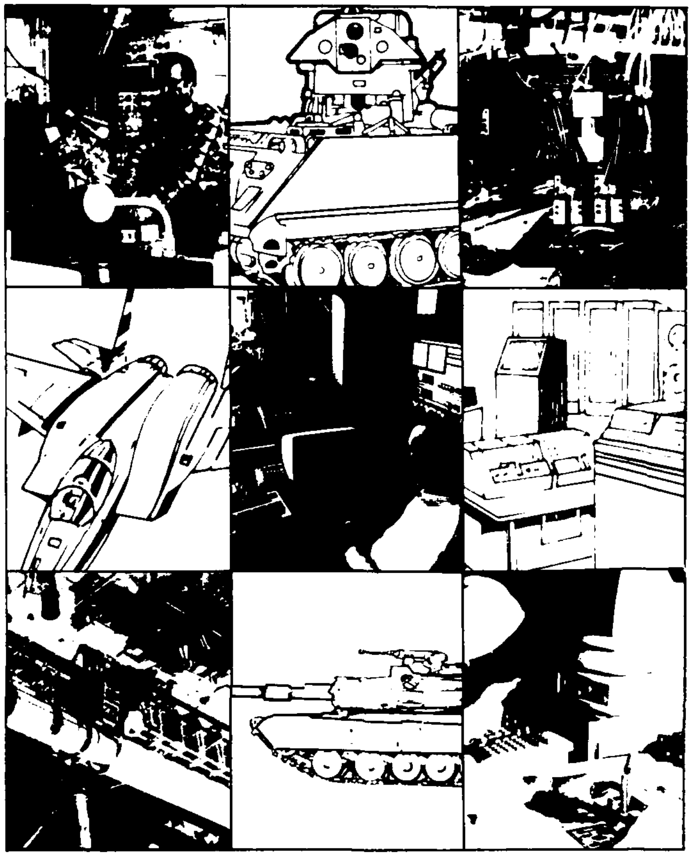
Dr. Waelchli grew up and was educated through Junior College in the Philadelphia suburbs. He was graduated from Penn State with a B.S. degree in physics and became a Federal Government Management Intern with the Navy Department. During the next 15 years, Dr. Waelchli held progressively more responsible Navy Department financial management positions, primarily in research and development. His postgraduate education includes an M.B.A. degree in applied economics and a doctorate in management science, both from The George Washington University. He was a member of the Academy of Management, the Society for General Systems Research, The American Society for Cybernetics, and Mensa.

Dr. Waelchli was an Adjunct Professor in the University of Maryland Graduate School; Research Associate, Center for Interactive Management, George Mason University; and Associate Professorial Lecturer in management science, The George Washington University. He was a lecturer for the University of Southern California (Systems Science Institute), and since 1984 was a faculty member, Navy Logistics Management School.

Dr. Waelchli is survived by his wife and two children.

MANUFACTURING MANAGEMENT:
A GUIDE FOR GOVERNMENT AND INDUSTRY

Professor David D. Acker *Lieutenant Colonel Sammie G. Young, USA*



Greg Caruth

At the Defense Systems Management College (DSMC) we are concerned about the role of defense manufacturing management and its impact on the quality and performance of defense systems. Most readers of this Journal will recognize that program management—the focus of educational endeavors at DSMC—is engaged in all facets of activity relative to the design, manufacture, test, and support of defense systems.

When does the concern of manufacturing managers on a defense system program begin? Manufacturing personnel should become active participants in initial stages of any new program. Further, design of a new defense system capable of production within a proposed cost and schedule is of concern to government and industry program managers in early phases of any program. Sometimes the period allowed for manufacturing personnel to be involved may have to be shortened, even though complexity of the design and the reliability requirements for the system or equipment being designed does not appear to justify shortening the process. In such cases, it is important that each organization involved in the program know how such a change affects its role.

In early stages of development, manufacturing may be able to suggest economical techniques to minimize costs. It is essential, therefore, that manufacturing personnel participate in trade-off discussions and design reviews, provide manufacturing guidelines and standards, and suggest automated design/manufacturing processes. The importance of early participation by manufacturing personnel needs to be emphasized because, by the time the design has been completed, approximately 90 per cent of the manufacturing cost has been "cast in concrete."

Objectives

Relative to the *Guide*, when DSMC published the first two editions (then called a *Handbook*), it assumed responsibility for publishing new editions whenever there were sufficient changes in policies, procedures, and practices to make it appropriate. It has become appropriate to release a new edition now.

Although the text has been revised, the basic objective has remained unchanged. The *Defense Manufacturing Management (DMM) Guide* is still one of a family of educational documents published by the College and written from a Department of Defense (DOD) perspective. These documents are used primarily in courses presented at DSMC and, secondarily, are desk references for program management personnel. We hope the new *Guide* will continue to serve their functions.

The April 1989 revision of the *DMM Guide* provides the reader with an understanding of, and a basic working familiarity with, effective manufacturing management methods used in defense systems acquisition programs. It is intended for the *Guide* to be useful in preparing for, and executing, the production phase of a defense system program. The *Guide* includes a discussion of DOD policies, directives, methodologies, and manufacturing practices, along with a list of acronyms and a glossary of terms, applicable to manufacturing management efforts of defense contractors throughout all phases of a program.

Basic activities associated with producing defense systems and associated equipment, current critical issues affecting manufacturing management, common causes (and cures, when known) of manufacturing problems, and lessons learned on past programs have been placed in focus. Manufac-

turing management considerations during the development, and the production phase of a program, have been addressed. The *Guide* has related the manufacturing function to the fielding of defense systems and subsequent logistics support activities.

Objectives Of And Approach To DOD Manufacturing Management

Objectives of DOD manufacturing management on a program are:

— To ensure that proper manufacturing planning has been accomplished early so that the manufacturing effort will be performed smoothly
— To ensure that the system design will lead to efficient and economical quantity manufacture
— To assess the program status at any point during the production phase to determine if schedule, costs, and quality standards are being met
— To conduct assessments and reviews of the manufacturing effort required to meet decision points at each program phase.

One of the basic thrusts within the DOD is to ensure adequate management attention to manufacturing and total quality management during the early defense system program phases. There are significant costs associated with the manufacturing effort and these costs, to a great degree, are inherent in the design. As a design evolves, some costs become almost fixed. Given the objective of minimizing cost and the existence of projections that indicate limited dollars available for future manufacturing effort, it is necessary to identify costs at that point in the program where they are being fixed. This situation provides the need for an early assessment.

The Undersecretary of Defense for Acquisition has the direct responsibility for DOD manufacturing management policy and guidance in the acquisition of defense systems. The head of each DOD component (military departments and defense agencies), in turn has responsibility for developing and implementing procedures within the components. The DOD Directive 5000.1, "Major and Non-Major Defense Acquisition Programs," established the approval cycle and procedures for defense system acquisition. Further, the directive established the Undersecretary of Defense for Acquisition as the Defense Acquisition Executive (DAE). The DAE is charged with assuring that the manufacture of each defense system is performed in a manner to ensure the production of the most efficient, cost-effective, and highest quality end-item possible.

The Guide has related the manufacturing function to the fielding of defense systems and subsequent logistics support activities.

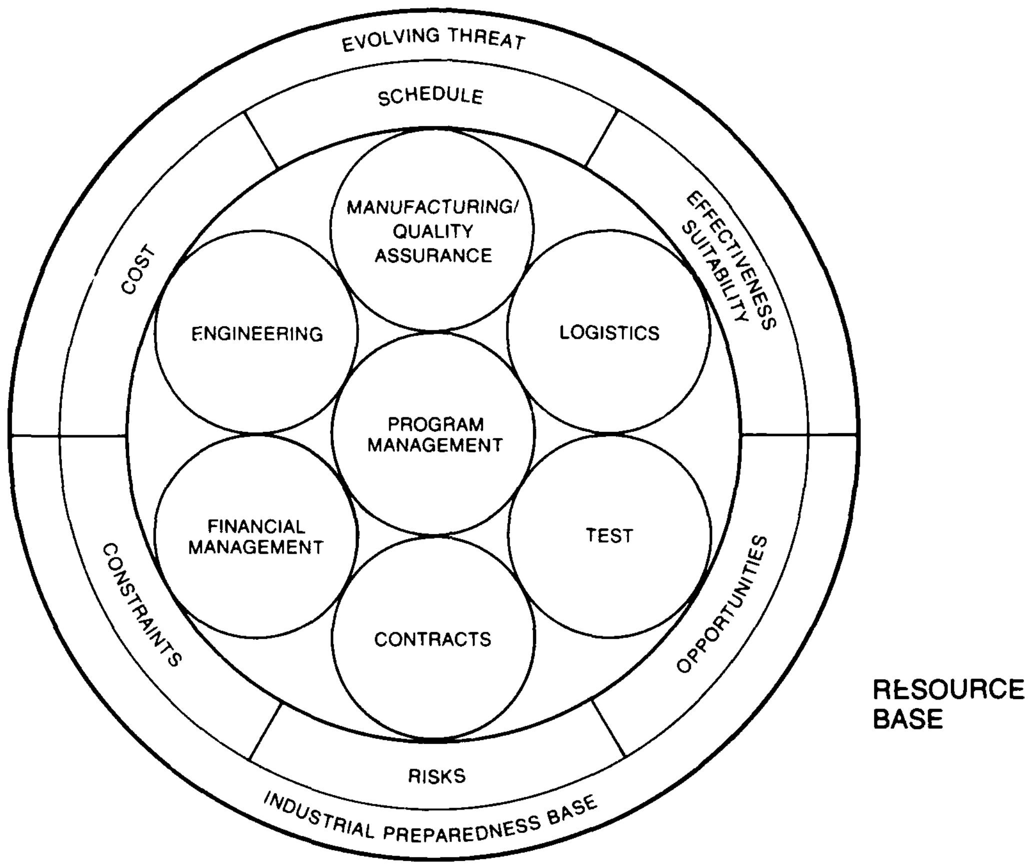
Principal Subjects Covered in Guide

The comments which follow are identified with the chapter to which they pertain in the new *Guide*.

Chapter I. Overview. This chapter is an overview of DOD manufacturing management.
Chapter II. Industrial Base provides the program manager with information to help in specifically accessing and understanding the capability of the industrial base to support a given program.
Chapter III. Product Development establishes a model of the process by which products are developed and produced for use. The generic development process described is a basis for integrating the specific manufacturing management activities discussed.
Chapter IV. Manufacturing Strategy describes development of a plan for assuring timely and cost-effective production of an item which meets operational effectiveness and suitability requirements. A vignette from the text is shown.
Chapter V Total Quality Management addresses TQM as it relates to the manufacturing process.
Chapter VI. Manufacturing Planning and Scheduling provides information on the identification of resources and their integration into a structure that provides the capability to achieve manufacturing objectives.
Chapter VII. Producibility provides information directed toward achieving a design compatible with realities of the manufacturing capability of the defense industrial base.
Chapter VIII. Manufacturing Technology identifies some mechanisms for describing and proofing manufacturing processes. It describes integration of advanced manufacturing technology into the manufacturing program.
Chapter IX. Manufacturing Cost Estimating focuses on identification and characterization of manufacturing costs as they are estimated and incurred by defense contractors.
Chapter X. Contracting Issues in Manufacturing provides information on a number of manufacuring management issues from the perspective of the contractual relationship.
Chapter XI. Transition from Development to Production discusses some organizational and functional issues involved in the transition from development to production and the process for evaluation and management.
Chapter XII. Manufacturing Surveys and Reviews identifies various types of surveys, reviews, and audits conducted by the government. Particular attention is paid to Production Readiness Reviews.
Chapter XIII. Manufacturing Controls concentrates on manufacturing controls necessary to ensure problems symptomatic of complex manufacturing environments do not disrupt acquisition programs.
Chapter XIV. Factory of the Future discusses how it will affect the way defense systems will be designed, produced, tested, and supported.

A VIGNETTE FROM THE TEXT

SYSTEM REQUIREMENTS/CONSTRAINTS



The Systems Acquisition Environment

Strategy, a long-term issue, focuses on definition of program objectives and development of an integrated approach to achieve the objectives. Manufacturing strategy, for example, is a detailed plan for assuring timely and cost-effective production of an item which meets operational effectiveness and suitability requirements. Measurable goals and milestones are supported by action plans which include underlying assumptions, allocation of responsibility, resource requirements, time and risks.

In addition to updating the chapters contained in the last edition, the third edition adds a chapter on Total Quality Management as it relates to manufacturing, and a new chapter on Manufacturing Technology.

As a manufacturing management problem or question arises, one should be able to turn to an appropriate section of the *Guide* and find helpful and pertinent information. Although it was not the intention of the Defense Systems Management College to provide an exhaustive treatment of any subject in the *Guide*, it provides sufficient information to be responsive to the needs of program management office personnel and students attending courses at the College or one of its regional centers.

Copies of the *Guide* will be available to students in many DSMC courses. In addition, it may be obtained from the Government Printing Office (GPO) and the Defense Technical Information Center (DTIC), Alexandria, Va. As of this writing, the cost of a copy sold by the GPO and the accession number assigned by DTIC are unknown.

Professor Acker is responsible for manufacturing management research at DSMC.

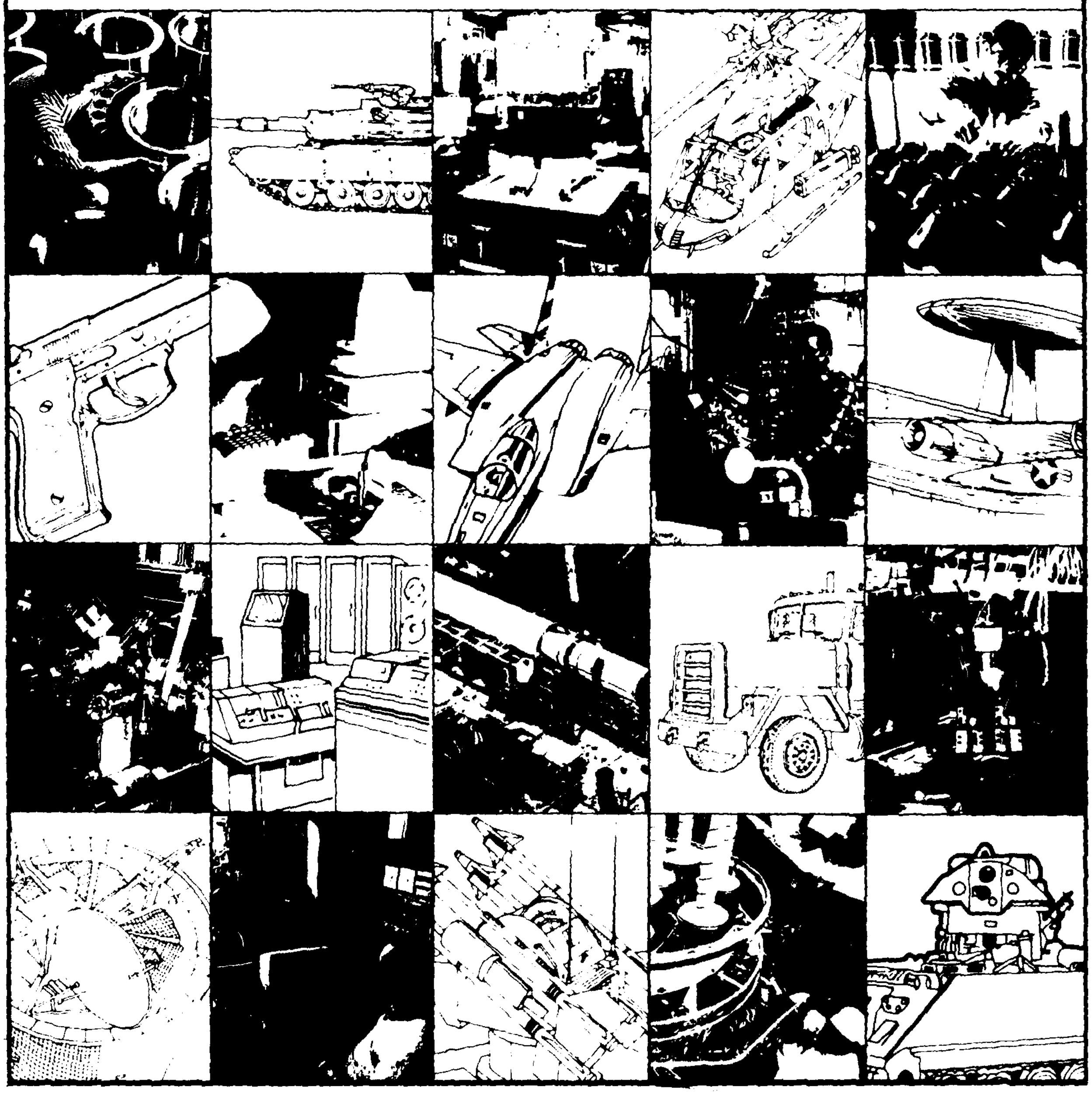
Lieutenant Colonel Young is a Professor of Engineering Management in the Technical Management Department at DSMC.

The authors served as the Contracting Officer's Representatives for the revision to the Guide.

DEFENSE SYSTEMS
MANAGEMENT COLLEGE

DEFENSE
MANUFACTURING MANAGEMENT
GUIDE FOR PROGRAM MANAGERS

APRIL 1989 THIRD EDITION



LIAO

(Continued from page 46)

Finally, one must keep in mind that *steep slope does not reflect efficiency in learning*. What it represents is the opportunity for learning. Other things being equal, a high first unit cost always results in steeper learning rate. On the other hand, extensive preproduction planning normally results in low production cost for the first unit and low learning rate.

Endnotes

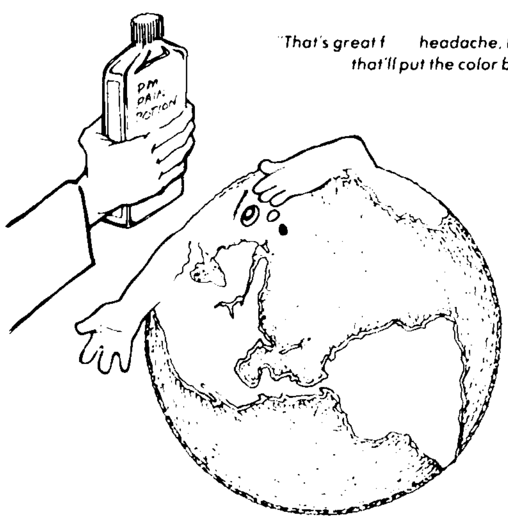
1. Daniel L. Johnson, "The Learning Curve: Which One to Use?" *Program Manager* (January-February 1987), pp. 7-10.
2. It should be mentioned that this is not the only possible formulation of the learning curve. One of the best known alternative form is the Stanford Research Institute investigation of 20 World War II aircraft. The study proposed $y = a/(x+b)^{1/2}$ as a more reliable expression of the relationship between man-hour cost and cumulative output.
3. R. D. Stewart and R. M. Wyskida, *Cost Estimator's Reference Manual*, John Wiley & Sons, 1987, p. 165.
4. See Johnson, op cit., and, Shu S. Liao, "The Learning Curve: Wright's Model vs. Crawford's Model," *Issues in Accounting Education* (Fall 1988), pp. 302-315.
5. Note that the algebraic midpoint formula was incorrectly listed in Johnson's article.

SHELTER USERS CONFERENCE IN JUNE

The Joint Technical Working Group (JTWG), Joint Committee on Tactical Shelters (JOCOTAS), and co-host Marine Corps Logistics Base, Albany, Ga., are sponsoring a shelter users conference in the Civic Center, Albany, June 20-22, 1989.

Tactical shelters and ancillary equipment from the Army, Air Force, Navy and Marine Corps will be on display to give potential shelter users the opportunity to view the variety of shelters and ancillary equipment available. The conference is open to government and contractor personnel.

For more information, contact Jim Spires, program coordinator; Telephone (202) 695-3072/3006, or AV 225-3072/3006.



"That's great f headache, Doc But I need something that'll put the color back in my cheeks!"

ICAF CONFERENCE

About 250 senior executives from industry, academia and government will meet in Washington with students of the Industrial College of the Armed Forces May 31 and June 1 for the eighth annual Mobilization Conference. The College, part of the National Defense University, provides a yearly forum when mobilization issues confronting the United States and its allies are addressed. Key speakers will include Lieutenant General Edward Honor, U.S. Army, Joint Chiefs of Staff Director for Logistics.

For more information, write to: Mobilization Conference, Industrial College of the Armed Forces, Fort McNair, Washington, D.C. 20319-6000; or call Commercial (202) 475-1812/1772 or Autovon 335-1812/1772. A registration brochure is available.

ICE CONFERENCE IS PLANNFD

The 13th Interservice Correspondence Exchange (ICE) Conference is scheduled for October 17-19, 1989, at Williamsburg, Va. The host unit is the Army Training Support Center, Institute for Professional Development (IDP), Fort Eustis, Va., which centrally manages and administers the Army Correspondence Course Program (ACCP).

This year's theme is "Solutions, Proven and Proposed, in Correspondence Education." The conference includes individual and concurrent presentations by speakers ranked among the best in their fields of education and training. Representatives of all branches of the military services will participate in an open exchange of ideas. Exhibitors and vendors will display the latest in technological innovation.

Anyone interested in learning more about the conference, as participant or attendee, may write Commander, U.S. Army Training Support Center, ATTN: ATIC-IPC, Marianne Raymond, Conference Coordinator, Fort Eustis, VA 23604-5121; or call Commercial (804) 878-4001, or Autovon 927-4001.

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Outstanding papers will be selected for presentation at the symposium and/or printing in the symposium "proceedings."

Selection of papers will be based on their relevancy to current issues in acquisition management.

Significant issues in defense acquisition management include, but are not necessarily limited to the following:

1. *Actions taken in response to recommendations from the President's Blue Ribbon Commission on Defense Management (Packard Commission).*

2. *Actions taken on TQM and the other nine initiatives of Dr. Robert B. Costello, Under Secretary of Defense for Acquisition.*

3. *Actions taken on the recommendations from the "Acquisition Leadership '88 Conference" on 14 July 1988.*

4. *Results of recent acquisition and acquisition management research.*

Papers must be received by 14 July 1989. Send to:

DSMC-DRI-R(ARS)
Fort Belvoir, VA 22060-5426

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NCMA